SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

AUGUST 1901.

GENERAL PHYSICS.

1468. *Hardness of Metals and Alloys.* **C. Benedicks.** (Zeitschr. Phys. Chem. 36. pp. 529–538, April 2, 1901.)—It has been shown that the hardness of steel depends on the carbon, in the form of carbide (C_2Fe_6), forming a homogeneous solid *solution* with the iron, the carbide being only mechanically *mixed* with the iron in soft steel. As in general a solvent increases but little in volume on dissolving small quantities of foreign substances, such solution increases the number of atoms present in a given volume, or the atomic concentration (density ÷ atomic weight). Bottone has shown that for twenty-four pure metals the hardness measured in a certain way is proportional to the atomic concentration, and other measures of hardness seem to confirm this conclusion. But, by Avogadro's law, atomic concentration in gases determines their pressure, and analogy therefore suggests that hardness in simple bodies may be of the character of a pressure, by which indeed under Herz's definition it is measured. The hardness of solid solutions, *i.e.*, of alloys, will thus be of the nature of an *osmotic pressure;* and this conclusion explains the facts of the varied hardness of iron when alloyed with different metals, and those, too, of the hardness of Cu-Sn alloys. R. E. B.

1469. *Determination of Gravitation Constant.* **J. F. Hayford.** (Science, 13. pp. 654–655, April 26, 1901.)—After reference to the differences between the results obtained in the absolute measurement of the gravitation constant by different observers at the same station using different instruments, the author outlines the system of comparative determinations which have been arranged by the International Geodetic Association from observations at Washington, Kew, London, Greenwich, Paris, and Potsdam. C. P. B.

1470. *Mercury Vacuum Pump.* **R. Federico.** (N. Cimento, 1. pp. 187–189, March, 1901.)—Guglielmo described a pump [Abstract No. 5 (1900)] acting by means of a Torrecellian vacuum, but having the disadvantage that its working required the use of two stopcocks. The pump described in the present paper is constructed on the same principle, but does away with the necessity of stopcocks. The principal bulb exhausts into a second bulb, from which it is shut off by a mercury seal in a U-tube, the second bulb being exhausted simultaneously, so that between the two there is but a small difference in pressure. G. H. B.

1471. *Pyknometer.* **M. Rudolphi.** (Phys. Zeitschr. 2. pp. 447–448, April 27, 1901.)—This instrument is intended for comparing the densities of two liquids. It consists of two concentric tubes of glass, closed at each end so as to form a jacketted cylinder. The ratio of the volumes of the inner and outer vessels can be very simply expressed. A sketch of the instrument is given, but there are no details as to the method of using it. R. A.

1472. *Superficial Tension: Drop Methods.* **P. A. Guye** and **F. L. Perrot.** (Archives des Sciences, 11. pp. 225–265, March, and 345–388, April, 1901; also Comptes Rendus, 132. pp. 1043–1046, April 29, 1901.)—Investigations are made into the conditions under which superficial tensions measured by drop methods would be really comparable with those obtained from capillary ascents in vacuo. A critical discussion is given of the bibliography of the subject. The weight of drops of the same liquid issuing from the same orifice is not the same for slow and for rapid formation of the drops; under ordinary conditions, as drops are formed more rapidly they become heavier. As the time of formation of the drop is lengthened the weight reaches a limit, beyond which any further lengthening of the time makes no difference; but even under these conditions the superficial tensions as calculated do not agree any better with those derived from capillary ascents, and no method of correction has as yet shown itself to be applicable. When we discriminate between drops completely formed and drops fallen off, we find that these are not always proportional to one another, and the liquid remaining adherent after the fall of the drop represents a fraction which varies from one liquid to another between 17 and 29 per cent. The best method for measuring superficial tensions by drop methods seems to be that of M. Duclaux, to let the drops form freely at the capillary orifice of a pipette calibrated beforehand with a standard liquid whose superficial tension is known. By introducing two corrections, one of which depends on the number of drops, the other on the rate of their succession, the superficial tensions may be obtained within 1 or 2 per cent., which is enough when the object in view is to ascertain whether the liquid studied has become polymerised or not. Many points remain for further investigation, which is promised. A. D.

1473. *Resistance of Air at Speeds below One Thousand Feet per Second.* **A. F. Zahm.** (Phil. Mag. 1. pp. 530–535, May, 1901.)—The projectiles used were wooden spheres about 4 inches diameter of different masses. Instead of making the balls break wires stretched across their path at different distances from the gun in order to measure the velocity, the wires were replaced by very narrow beams of light, and the chronograph was of the form of a photographic plate falling freely under its own weight.

The results are found to satisfy the formula $R = av^2 + bv^3$, deduced theoretically in 1842 by Duchemin. When expressed in lb. ft. sec. units the formula becomes—

$$R = 0{\cdot}000008v^2 + 0{\cdot}000000049v^3.$$

J. B. H.

1474. *Work of the Reichsanstalt in* 1900. (Zeitschr. Instrumentenk. 21. pp. 105–121, April, and 138–155, May, 1901.)—This summary of the work done during the year 1900 in the Reichsanstalt is divided into two parts, dealing with the work of the Research department and the Testing department respectively. The list of researches done in the former under the heading Heat includes density of water vapour at 100° C., density of water vapour at room temperature, vapour pressure of water vapour at 50°, measurements of high temperatures and determination of melting-points of a number of metals, expansion of metals at high temperatures, measurement of low temperatures by a petrolether thermometer and standardisation of the platinum thermometer at the same temperatures, heat conductivities of metals, conductivity of heat through hot surfaces, and work with Fizeau-Abbe's dilatometer. The electrical researches are: Construction and standardisation of standard resistances and standard cells, measurement of the capacity of an air condenser by Maxwell-Thomson method, and conductivity of solutions. The optical researches have all been connected with radiation.

The second part, extending to fifteen pages, which deals with the work of the Testing department, contains little more than lists of the various instruments tested during the year; but where improvements have been made in the methods of testing a short description of the same is given.

Abstracts of many of the researches have already been published in these pages. The number of persons engaged in the Reichsanstalt is 96, 35 being scientific workers, 41 technical workers, and 20 clerks and subordinates.

J. B. H.

1475. *Theory of Capillarity.* **G. Bakker.** (Zeitschr. Phys. Chem. 36. pp. 681–692, April 19, 1901.)—This is a treatise on the differential equation of capillarity. We are to suppose a homogeneous medium the parts of which behave to each other as regards their mutual forces as the various molecules or atoms in capillary phenomena. If these mutual forces have a potential, it must in the interior vary as the density, and in the exterior space diminish rapidly to zero along the normal to the bounding surface. These conditions are expressed for the potential V by the equation $\nabla^2 V = q^2 V + 4\pi f\rho$, where ρ denotes density, and q and f are constants, provided q be great enough.

The author proceeds to transform this equation by means of a system of curvilinear co-ordinates, whose elements are ∂u, ∂v, ∂n. He obtains the result—

$$\frac{\partial \frac{dV}{dn}}{\partial n} + \left(\frac{1}{R_1} + \frac{1}{R_2}\right)\frac{\partial V}{dn} = q^2 V + 4\pi f\rho,$$

where R_1, R_2 are the principal radii of curvature to the surface to which ∂n is normal.

He then considers the molecular pressure and surface tension. The former can be calculated from the last written differential equation. In the special case of no external forces the *uv* surface is a level surface of the potential of the capillary forces. As in his former papers the author discusses the relation between V as defined by the above equation and Laplace's constants K and H, remarking that Laplace assumes the density of his liquid to be constant up to the boundary. In the present paper the constancy is assumed only within the capillary layer.

In his concluding section he introduces the surrounding medium—*e.g.*, vapour of the liquid—into the theory, assuming it not only to exert uniform pressure on the surface, but to contribute to the potential V. This is discussed with reference to the theories of Laplace and van der Waals. S. H. B.

1476. *Vitrified Quartz.* **W. A. Shenstone.** (Nature, 64. pp. 65–67, May 16, 1901. Paper read before the Royal Institution, March 8th.)—A lecture on the preparation and properties of vitrified quartz. The author describes his method of making tubes of this material, pointing out the difficulties to be overcome. When once prepared, these tubes are for many purposes much superior to glass tubes, as, for example, for use in thermometry. The mean coefficient of expansion of a rod of vitrified silica is only 0·000,000,59; its expansion is exceedingly regular up to 1,000°, and if not heated beyond this temperature it returns very exactly to its original length when cold. Above 1,000° the rate of expansion diminishes rapidly, changing to a contraction at about 1,200°. Experiments on the transparency of this substance to ultra-violet rays show that tubes made of it are much more suitable than glass ones for use in studying the spectra of electric discharges. Its most remarkable property is its behaviour under sudden changes of temperature. When white hot it may be plunged into cold water, or even into liquid air, without injury. For use in thermometers, and for researches on pure gases and on the behaviour of gases at high temperatures, it should prove much superior to glass. It has some defects, however, as it is slightly permeable to hydrogen at about 1,000°, and it is attacked, when hot, by alkaline oxides. W. C. H.

1477. *Mechanical Compensation for the Rotation of the Field in the Siderostat and Heliostat.* **A. Cornu.** (Comptes Rendus, 132. pp. 1013–1017, April 29, 1901.)—The fact that these instruments only bring one point of the field to rest, while the other points revolve round it, causes inconvenience, especially in photographic work. Devices, practical and theoretical, have recently been brought forward for counteracting the rotation of the field by imparting an equal rotation to the photographic plate. The author points out that the problem can be solved by means of the well-known mechanism called Hooke's joint (*"joint universel, ou croisillon"*). If the rotations round the two axes of a Hooke's joint are measured from properly chosen zero points, the tangents of the rotations are in a constant ratio, this ratio being the cosine or secant of the inclination of the axes.

The rotation of the field of the siderostat is governed by the relation—

$$\tan\frac{Y}{2} = K\tan\frac{H-\omega}{2}, \text{ with } K = \frac{\cos\frac{1}{2}(\rho+\delta)}{\cos\frac{1}{2}(\rho-\delta)},$$

Y being the rotation of the field, ω the hour-angle of the fixed reflected ray, H the hour-angle of the corresponding incident ray. The two axes of the Hooke's joint must be set at an angle whose cosine or secant is equal to K. This solution has the advantage of only involving rotations about pivots, which are easily realised and involve a minimum of friction. The adjustments necessary for securing accuracy would, however, be troublesome to carry out (though not more so than in the other methods which have been proposed). This is the reason why the author, who has long been familiar with this solution, has not published it before. A. E.

1478. *Comparison of Photographic Magnitudes of Stars of Different Colours.* **K. Schwarzschild.** (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 1127–1134, 1900.)—In comparing the photographic effect of light of different colours, a difficulty is met with analogous to the Purkinje phenomenon in visual optics (by which the red end of the spectrum appears to grow brighter relatively to the blue as the intensity of the light increases). Two differently coloured sources which, in the same time, darken the film to the same extent, will no longer do so when the time is altered, or when the intensities of both sources are increased in like proportion. The effect, however, is largely masked by the superior sensitiveness in the blue (max. about 450$\mu\mu$) of the silver bromide plates in common use. In considering celestial photographs one might expect the effect to be negligible except for decidedly red stars. With the view of testing how far this was the case, the author selected several close pairs of stars, in which the components of each pair, while nearly equal photographically, differed in visual brightness (in some cases by more than a magnitude). Each pair was photographed with a series of exposures ranging from 30 seconds to 1½ hours, on plates placed at two different distances from the focus. No alteration in the relative photographic magnitude of the components was found under these circumstances for any pair. The author makes frequent use of the term "relative actinity," which he defines as the ratio of the photographic brightnesses of two sources divided by the ratio of their visual brightnesses. A. E.

1479. *Magnetic Theory of Solar Corona.* **F. H. Bigelow.** (Amer. Journ. Sci. 11. pp. 253–262, April, 1901.)—The probable connection between the form of the solar corona and the discharge from an electrified conductor when subjected to a magnetic field has been urged at various times since 1889 by the present author and others. Discussion of the measures obtained from the coronal pictures obtained in 1898 and 1900 tends to greatly confirm this view, and a discussion is given in the paper of the probable effect of magnetic disturbances at the sun's surface on the meteorological phenomena on the earth. It is pretty generally accepted that the electrical state of the atmosphere is associated with the varying tension of water vapour, and the distribution of water-vapour zones is described in this connection, a process of ionisation of the particles of water vapour being supposed to be induced by the magnetic radiation from the sun.

The paper also contains useful references to the experimental work of Pupin, Ebert, Elster and Geitel, and others. C. P. B.

1480. *Solar Radiation.* **J. Violle.** (Annal. Chim. Phys. 22. pp. 329–370, March, 1901. Report presented to the International Meteorological Committee at St. Petersburg in 1899.)—The report is in two parts, preceded by a brief historical review of the chief methods employed for determining the solar radiation. The first part contains descriptions, not illustrated by diagrams, of some instruments and notes on their application, namely instruments of Violle, Crova, Ångström, &c. The second part contains a discussion of formulæ. We have now excellent observatory apparatus for the determination of solar radiation, and also portable instruments, but no meteorological instruments of sufficient simplicity and strength. Owing chiefly to the unknown absorption in the higher atmospheric strata, the solar constant remains uncertain. Further balloon observations at high elevations are needed. H. B.

1481. *Age of the Earth.* **P. Rudzki.** (Acad. Sci. Cracovie, Bull. 2. pp. 72–94, Feb., 1901.)—The writer refers to Joly's memoir on the same subject, to R. O. Fisher's comment thereon, and to Kelvin's discussion given in Thomson and Tait's "Natural Philosophy," Appendix A. According to Fourier's theory of heat, if the temperature in a sphere of radius R gradually cooling be a function of the distance from the centre, the contraction is expressed by—

$$\frac{dR}{dt} = -\frac{3\mu k}{\gamma},$$

in which k is the coefficient of thermal conductivity, γ the gradient of temperature in the superficial layer, and μ the coefficient of linear dilatation with increase of temperature. It is assumed that at a time $t=0$, which must have been before the commencement of the Silurian age, the earth was at uniform temperature : $t=t_1$ denotes the commencement of the Silurian age, and $t=t_2$ the present time. The object is to find a value for t_2-t_1, which shall be, if not approximately correct, at least correct as regards order of magnitude.

According to Kelvin we take $\gamma=c\sqrt{t}$,

whence— $\gamma_1=c\sqrt{t_1} \qquad \gamma_2=c\sqrt{t_2}$,

or— $c=\gamma_2/\sqrt{t_2}$.

And γ_2 is known by observation. If ΔA be the diminution of the earth's surface by contraction since the beginning of the Silurian age, we find—

$$\Delta A=\frac{48\mu k\pi R}{\gamma_2}\sqrt{t_2}(\sqrt{t_2}-\sqrt{t_1}),$$

whence—

$$t_2-t_1=\frac{\gamma_2}{48\mu k\pi R}\cdot\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}}\Delta A,$$

and the maximum value of $\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}}$ is 2 if $t_1=t_2$, and its minimum is unity if $t_1=0$. The former limit corresponds to the hypothesis that t_2-t_1 is infinitely small compared with t_2 or t_1, and that γ_2 may be treated as constant with regard to time. The limit $t_1=0$ corresponds to the hypothesis that at the beginning of the Silurian age the earth's temperature was constant.

To calculate ΔA the author assumes that the diminution of surface area is equal to the area of the foldings which have taken place since the epoch in question, and this he essays to calculate from known geological data respecting the various continents and islands and the depth of the adjoining oceans. Taking the lowest estimates, he finds—

$$\Delta A=-8{,}080{,}000 \text{ square kilometres.}$$

He then considers the coefficients μ and k, as to which there is much uncertainty. On the hypothesis $\frac{\sqrt{t_2}+\sqrt{t_1}}{\sqrt{t_2}}=1$, the estimates vary from $t_2-t_1=478{,}000{,}000$ years to Perry's estimate, 9,600,000.

The above discussion is on the assumption that the earth is to be treated as solid throughout. The writer concludes with a discussion of the difference which will be caused by the assumption that it is liquid or gas. S. H. B.

1482. *Air Barometer.* **H. A. Naber.** (Ann. d. Physik, 4. 4. pp. 815–827, April, 1901.)—After some historical notes the author gives descriptions of three barometers of his own. The first indicates barometric variations, and consists of a cylinder, fitted with cocks above and below, immersed in water or petroleum ; a coil, surrounding the cylinder, starts from below the upper cock, and is open at its lower extremity. The second instrument is a tubular pocket barometer on Hooke's principle, partly filled with water and containing an air and a mercury thermometer so adjusted that their relative heights remain unaffected by temperature. The third is a hydrogen voltameter based on Boyle's law ; it was described in *The Electrician* (1894). H. B.

LIGHT.

1483. *Transparency of Hydrogen.* **V. Schumann.** (Ann. d. Physik, 4. 3. pp. 642–645, March, 1901.)—Photographs were taken of that part of the spectrum of wave-length under 185 $\mu\mu$ with and without the hydrogen present. When an indiarubber tube of 50 cm. long connected the absorption tube and the apparatus for generating the hydrogen, the transparency of the hydrogen appeared to have suffered. When the rubber connecting tube was replaced by a glass one the hydrogen seemed more transparent than the vacuum which was alternated with it in taking the photographs. This is accounted for by the presence of vapours of mercury and fat in the exhausted absorption tube which would not be present to the same extent when the tube was filled with hydrogen at atmospheric pressure. E. H. B.

1484. *Influence of Temperature on the Absorption of Light by Solids.* **J. Koenigsberger.** (Ann. d. Physik, 4. 4. pp. 796–810, April, 1901.)—The influence of temperature on the absorption of light by various solids has here been experimentally determined for the temperature interval 10°–360°. Three different forms of spectral photometer were used; the final and most accurate form (0·4 per cent.) will be described in another paper.

The experimental results are summarised as follows:—

(1) In solid bodies having a selective absorption a rise of temperature moves the absorption curve in the direction of the longer wave-lengths, and in some cases simultaneously increases slightly the width of the absorption band; the magnitude of the maximum absorption is not appreciably altered.

(2) In metals the absorption is not influenced by temperature within the limits 10°–360° (for platinum up to 800°).

The author deduces from these experiments the influence of temperature on the refractive index and the dispersion in qualitative agreement with experimental results under the assumption that the dielectric constant always diminishes with increase of temperature. Some considerations are also added as to the light which a body should emit when heated. J. B. H.

1485. *Interference Bands Produced by a Thin Wedge.* **H. C. Pocklington.** (Cambridge Phil. Soc., Proc. 11. pp. 105–106, April 22, 1901.)—If light from a monochromatic source be caused to fall on a thin wedge of air contained between two pieces of glass which are kept apart at one side by a piece of paper but touch at the other side, interference bands are produced. The author discusses the conditions necessary for the bands to be clear and well defined, and deduces the formula connecting the angle of the film, the angle of incidence, and the distance between the bands. He has subjected his formulæ to experimental verification, and using rough apparatus has obtained results correct to about 1 per cent. W. C. O.

1486. *Graphical Study of Deviation by a Prism.* **P. Lugol.** (Journ. de Physique, 10. pp. 339–341, May, 1901.)—In the following, i, i' are the angles of incidence and emergence; r, r' the corresponding angles within the prism. To find the deviation, draw the curve of sines $y = \sin x$ (1), and also the curve $y = \frac{1}{\mu}\sin x$ (2), μ being the index. Let a line Pp, parallel to the axis of x, cut (1) at p, and (2) at P; and let n, N be the feet of the ordinates at p, P. Then $\sin ON = \mu \sin On$, and hence if $ON = \iota$ we have $On = r$, and Nn is the deviation at the first face. Let M, m be the feet of ordinates at points where a second line parallel to x cuts the two curves. Cut off OA on the axis of x equal to half the angle of the prism. Now if m and n be at equal distances from A on opposite sides, then $Om = r'$ (since $r + r' =$ angle of prism $= 2OA$). Hence $OM = i$, and $Mm =$ deviation at second face. An ordinate is erected at N equal to $Mm + Nn$, the whole deviation, and its end traces a curve showing variation of deviation with incidence-angle. Various properties are deduced from the construction. A. E.

1487. *Double Refraction in Liquids.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. 3. pp. 161–171, March, 1901.)—The author discusses the theory of accidental double refraction in liquids, examining only that part of the problem which can be attacked by the principles of hydrodynamics alone. He imagines a cylinder capable of rotation upon its axis. Concentric with this and at a little distance from it is another fixed cylinder, the space between the two being filled with the liquid under examination. He supposes the liquid incompressible and equations are established from which the deformation can be calculated. If the liquid be traversed by a beam of light parallel to the axis the double refraction resulting should be proportional per unit length to the true deformation. He draws the conclusion that there is no foundation for supposing that the accidental double refraction in a liquid depends only on its viscosity. W. C. O.

1488. *Optical Activity of Ethers and Esters.* **P. A. Guye.** (Chem. Soc., Journ. 79. and 80. pp. 475–476, April, 1901.)—The rotatory power of benzyl amyl ether resembles that of the *n*-butyl, rather than the phenyl or tolyl amyl ethers, and similarly amyl phenylacetate and phenylpropionate resemble the chloroacetate and propionate, rather than the benzoate and toluates. These are special cases of the general law that when substitutions of chains or groups of elements are effected in an asymmetric carbon compound in positions sufficiently far removed from the asymmetric carbon atom, the rotatory power is only slightly affected. T. M. L.

1489. *A New Interference Method of Resolving very close Spectrum Lines.* **O. Lummer.** (Deutsch. Phys. Gesell., Verh. 3. 7. pp. 85–98, 1901.)—In a former paper (Wied. Ann. 23. pp. 49–84, 1884) the author discussed the interference rings seen on looking through a very truly parallel transparent plate at a homogeneous light of measurable dimensions, with the eye accommodated to infinity, or, better, with a telescope. (See Drude's Optek, pp. 134–145.) To the properties previously enumerated he now adds another —that mentioned in the title. These rings are due to interference of rays reflected at the two surfaces, and the difference of phase depends only on the inclination of the rays to the normal. The difference between consecutive rings alters with this inclination, being least for some value between 0° and 90°. If the source of light be duplex, each component has its own set of rings, and the appearance of the component system changes with the angle of incidence, for certain values of which the maxima of one system fall on the minima of the other. The coincidence, however, is not necessarily exact; the two systems will only extinguish one another completely under certain conditions. The author examined the yellow lines of the Hg spectrum with an apparatus arranged in the following order: Mercury lamp, collimator tube, Rutherford prisms, small adjustable opening, large glass plate 5·3 mm. thick, telescope. It was found best to arrange the prismatic dispersion so that, with fairly wide slit, lines three times as far apart as the D lines were separated. Now Perot and Fabry have shown that each of the two yellow Hg lines has a faint and very close companion. The author calculated the appearances which ought to be presented by the complex system of rings due to the principal lines and their faint companions. The results of observation were in complete accordance with the prediction. With incidence sufficiently oblique, in both yellow images of the slit, besides the principal bands, auxiliary interference bands were seen, their relative positions being different in the two images. Observations were also made with reflected and polarised light. Other methods of producing the rings are described, and kindred investigations by Michelson and by Perot and Fabry are discussed. It is pointed out how the variation of intensity and the sharpness and resolving power of the rings may be calculated. A. E.

1490. *Anomalous Dispersion of Carbon.* **R. W. Wood.** (Phys. Soc., Proc. 17. pp. 657–663, July, 1901; and Phil. Mag. 1. pp. 405–410, April, 1901.)—The author, in attempting to determine whether the rapid decrease in amplitude of the wave front resulting from the passage of a wave through a prism of some strongly absorbing substance had any influence upon the direction of propagation of the ray, had recourse to a film of smoke on glass, hoping thereby to obtain a substance which would cause a decrease in amplitude without retardation or change of phase. The result, however, showed a very marked retardation. This the author suggests might be due to diffraction, an increase of path being introduced owing to the passage of the light round the carbon particles. If this were the true explanation, in such a film dispersion should be absent, or else there should be a greater retardation for the long waves than for the short.

A prism of finely divided carbon was constructed by taking a piece of plate glass and passing it slowly backwards and forwards over a flame, and the prism so formed was judged by the regularity of the interference pattern which it exhibited by reflected light. Having procured a suitable one, it was covered with a piece of paper perforated with two rectangular openings of equal width, one being placed over the smoked portion, the other over the unsmoked portion.

The prism was then placed upon the stand of a spectrometer, and the opening over the smoked portion closed, and the position of the image of the slit noted, this, of course, being undeviated. This opening was then closed and the other opened, and the position of the image of the slit produced by the light which has passed through the carbon prism read off. This was done with both blue and red light, and the mean for blue was found to be 48·6, while for red the mean deviation was 57·2. Thus the long rays show greater retardation than the short ones. The deviation produced was about 48 seconds. The results obtained are what would be expected if the diffraction theory were true, though they do not prove it. W. C. O.

1491. *Lamps for Spectrum Analysis.* II. and III. **E. Beckmann.** (Zeitschr. Phys. Chem. 35. pp. 443–458, and 652–660, 1900.)—In Part II. the author describes various auxiliaries for use with the lamp devised by him, such as apparatus for cooling the solution and washing the trough, various arrangements for forcing the air through the porous tubes, &c.

Part III. contains descriptions of a "universal lamp" for observations with the flames of coal-gas, hydrogen, or detonating gas, and of a sodium lamp for demonstration work. [See also Abstract No. 2419 (1900).] T. H. P.

1492. *Spectra with Self-Induction Spark.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 959–962, April 22, 1901.)—A long series of experiments are described showing the gradual changes in the spectrum of an electric spark when the self-induction in the secondary circuit is varied. Photographs of many of these are given with the paper.

From the differing behaviour of the various lines the author distinguishes three classes of spectrum lines :—

(1) Those lines whose intensity diminishes rapidly with increase of self-induction. These are the lines of air and the high-temperature or short lines of metals, *e.g.*, the doublets of zinc and cadmium ; 4481 magnesium, 4244·9 and 4386·6 of lead.

(2) Those lines which slowly diminish in intensity and in a continuous manner with increase of self-induction. These correspond to the arc lines of the metals, *e.g.*, the triplets of magnesium.

(3) The lines which diminish at first to a minimum, and then begin to increase again as the self-induction is further increased. The greater number of the lines of Fe and Cu belong to this class.

[See also Abstract No. 2159 (1900).] C. P. B.

1493. *Villari's Osbservations on Electrical Discharge by Röntgenised Air.* **E. Dorn.** (Phys. Zeitschr. 2. p. 433, April 20, 1901.)—From Zeleny's experiments on the velocity ratio of positive and negative ions in an electrical field, for air and damp carbon dioxide, the author deduced that in Villari's experiments these gases would give discharges of opposite sign. [See Abstract No. 800 (1901).] Villari [see Abstract No. 1072 (1901)], however, found the discharges to be of the same sign, but weaker in the case of carbon dioxide. In the meantime, the author found that the ratios given by Townsend [see Abstract No. 59 (1900)] and Chattock, Walker and Dixon [see Abstract No. 848 (1901)] differed from Zeleny's, and, taking the latter's figures, his deductions agree with Villari's experimental results. He recommends that Villari's apparatus be constructed throughout of the same metal. G. H. B.

1494. *Action of Radium Rays on Selenium.* **E. Bloch.** (Comptes Rendus, 132. pp. 914–915, April 15, 1901.)—Following Smith's discovery that the resistance of selenium is lessened by the action of light, Perreau has shown that Röntgen rays have a similar action [Abstract No. 628 (1900)]. In the present paper it is shown that radio-active substances produce a similar result, although somewhat more slowly. A selenium element having an initial resistance of 80,100 ohms falls rapidly to 1,000 ohms under the influence of a feeble diffuse light. On being placed about 1 mm. from a layer of carbonate of barium having the same area, the resistance falls in ten minutes to 29,000 ohms. When the salt is removed, two hours are required for it to rise to its normal value. This result is not due to the phosphorescent glow from the salt, as this was cut off by the interposition of several thicknesses of black paper. It is thought that this fact is in favour of the idea that the radium rays are a mixture of kathode and Röntgen rays. R. S. W.

HEAT.

1495. *Radiation Equation for Polished Platinum.* **D. A. Goldhammer.** (Ann. d. Physik, 4. 4. pp. 828–838, April, 1901.)—In Kirchhoff's equation,

$$\frac{e_\lambda}{a_\lambda}=\epsilon_\lambda,$$

a_λ may be shown to be an algebraic function of λ. It follows, therefore, that if the expression for ϵ_λ contains a transcendental function, then e_λ must also contain the same function.

It is next shown that the formula deduced by Lummer and Pringsheim from their experimental results and which makes the total radiation of platinum nearly proportional to the fifth power of the temperature, can only be looked on as an empirical result and not as expressing a law. According to the same observations $e_m T^{-6}$ seems to remain almost constant. This is here shown to be theoretically impossible.

The formula—

$$e_\lambda = CT^5 \frac{\psi(T)}{(\lambda T)^5} e^{-\frac{c}{\lambda T}}$$

is shown to represent closely the radiation of polished platinum, but this formula and Thiesen's formula,

$$\epsilon_\lambda = \frac{CT^5}{(\lambda T)^{4 \cdot 5}} e^{-\frac{c}{\lambda T}}$$

cannot both be correct. Thiesen's formula gives for high temperatures values of ϵ_λ several per cent. greater than the observed values, and Planck's new formula gives at these temperatures values still greater than Thiesen's.

J. B. H.

1496. *Radiation of Black Bodies.* **H. Rubens** and **F. Kurlbaum.** (Ann. d. Physik, 4. 4. pp. 649–666, April, 1901.)—By means of the residual radiation from quartz the authors are able to extend to shorter wave-lengths (8·85 μ) their test [see Abstract No. 871 (1901)] of the various equations for the distribution of energy in the spectrum. The formulæ of Lummer and Jahnke, and of Planck agree very well with the observations for this region, the latter being simpler but showing small deviations of an apparently systematic character.

W. E. T.

1497. *Generalisation of Trouton's Law.* **de Forcrand.** (Comptes Rendus, 132. pp. 879–882, April 9, 1901.)—Trouton formulated the law that the heat of vapourisation is proportional to the temperature, on the absolute scale, of the boiling-point. The author discusses this law and the additions made to it by Le Chatelier, and finds that the general law can be more correctly expressed thus:—In all physical or chemical phenomena, the heat of solidification of any gas is proportional to the temperature of its boiling-point at atmospheric pressure; or, in symbols, $\frac{L+S}{T}=$ constant, where L = heat of liquefaction of a gas molecule, and S = heat of solidification of this liquid molecule. This law can only be rigorously verified in the one case of CO_2, as its melting-point, — 78·5° C., is exactly the same as its boiling-point at atmospheric pressure. From the experiments of Favre on the heat required to vaporise a given quantity of solid CO_2, we get for the above ratio 32·1, and 32 is exactly the value given by the dissociable ammoniacal chlorides. For other cases there is a more or less considerable interval between the temperature of solidification and the boiling-point; but as the value of S is always fairly small compared with that of L, we may, no matter what this interval be, use the value of S determined directly at the melting-point, without introducing a large error. The author finds as the mean of the ratios for fourteen different bodies the value 30. W. C. H.

1498. *Latent Heats of Evaporation.* **L. Kahlenberg.** (Journ. Phys. Chem. 5. pp. 215–232, April, 1901.)—A description, with figures, is given of a modification of Berthelot's latent heat apparatus. The boiling of the liquid is brought about by a spiral through which an electric current is passed, by which means superheating of the vapours before passing into the condenser is obviated. By using liquids of known latent heat the apparatus is found to give good results. The following mean values were obtained by it: Pyridine, 104·0; acetonitrile, 173·6; benzonitrile, 87·7; the first two of these numbers differ somewhat from those obtained recently by Louguinine [see Abstract No. 1038 (1900)]. Inserting the above values in the Arrhenius-Beckmann formula, the numbers 28·8, 48·67, and 14·39 are obtained for the boiling-point constants of pyridine, benzonitrile, and acetonitrile respectively. The Trouton-Schiff rule gives, according to Werner, the numbers 29·5, 45·70 and 13·91, while the same author obtained experimentally the values 30·07 and 36·55 for pyridine and benzonitrile respectively. T. H. P.

1499. *Liquefaction of Hydrogen.* **M. W. Travers.** (Phys. Soc., Proc. 17, pp. 561–575; Discussion, pp. 575–576, July, 1901; and Phil. Mag. 1. pp. 411–423. April, 1901.)—An account of the method whereby the author has succeeded in obtaining liquid hydrogen in quantity. The apparatus consists essentially of a modified Hampson air-liquefier. The hydrogen, at a pressure of 200 atmospheres, undergoes a preliminary cooling to —80° C. in solid carbonic acid and alcohol. It is then successively cooled by liquid air boiling under atmospheric pressure, and under a pressure of 100 mm., after which it escapes from the Hampson valve, and being a sufficiently imperfect gas at the low temperature (—200° C.) obtained by the liquid air boiling under low pressure, regenerative cooling is produced, as in the liquefaction of air by the Hampson machine, and liquid hydrogen is obtained. It is collected in a vacuum vessel which is specially insulated from external heat. For further details reference must be made to the original paper which is illustrated by a plate. F. G. D.

1500. *Platinum Thermometry in Cryoscopic Researches.* **P. Chroustchoff.** (Comptes Rendus, 132. pp. 955–957, April 22, 1901.)—The author gives details of the platinum resistance thermometer employed in his cryoscopic researches [see Abstract No. 413 (1901)]. It is a modification of Callendar and Griffiths' instrument, from which it differs to some extent in arrangement. The head of the instrument, *i.e.*, the point where the four wires for introducing the current are joined, is made with a strong plate of ebonite covered with a thick layer of paraffin. This perfect insulation of the head of the thermometer is of essential importance if readings of the order of thousandths of a degree are to be made. Moreover, the current from a large accumulator can be kept constantly passing through the Wheatstone bridge, the galvanometer, which is very sensitive, being introduced into the circuit only at the moment of reading. The three branches of the bridge, two of which are made equal within about the one hundred-thousandth of an ohm, the third having a resistance equal to that of the electric thermometer, are immersed in an insulating hydrocarbon bath. Corrections for the changes of temperature of the third branch of the bridge are eliminated by making blank experiments with the pure solvent used in the cryoscopic determinations. T. H. P.

1501. *Clapeyron's Equation.* **P. Saurel.** (Journ. Phys. Chem. 5. pp. 256–258, April, 1901.)—For the thermodynamic potential $\Phi \equiv E - t\eta + pv$ we have $d\Phi = -\eta dt + v dp$, and hence

$$\partial(\Phi,t)/\partial(\eta,v) = v\,\partial(p,t)/\partial(\eta,v).$$

For a univariant system p is a function of t, whence the second Jacobian vanishes, and therefore also the first, so that Φ too is a function of t, and also $d\Phi/dt \equiv -\eta + v\,dp/dt$; we therefore have

$$0 = \partial(-\eta + v\,dp/dt, t)/\partial(\eta,v) = -(\partial t/\partial v)_\eta - (dp/dt)\,(\partial t/\partial \eta)_v,$$

whence Clapeyron's equation—

$$dp/dt = (\partial \eta/\partial v)_t.$$

R. E. B.

REFERENCES.

1502. *Isothermals of Ether between* 100° *and* 206°. **E. Mack.** (Comptes Rendus, 132. pp. 952–955, April 22, 1901.)—With apparatus similar to that previously employed for another purpose [see Abstract No. 47 (1899)], the author obtained thirteen isothermals for ether at temperatures beginning at 100·95° and ending at 206·3°. The pressures ranged from 34 to 1,377 kg. per sq. cm. The results, which are tabulated, are in good agreement with the researches of Amagat, and Ramsay, and Young. E. H. B.

1503. *Behaviour of Ether at Constant Volume.* **E. Mack.** (Comptes Rendus, 132. pp. 1035–1037, April 29, 1901.)—The values of the volume of ether given in a previous paper [see preceding Abstract] verify a very simple law discovered by Amagat, namely, that at constant volume the increase of pressure is proportional to the rise of temperature. E. H. B.

1504. *Van der Waals' Equation.* **H. Hilton.** (Phil. Mag. 1. pp. 579–589, May, and 2. pp. 108–118, July, 1901.)—This equation in its reduced form is mathematically discussed as representing a family of curves with θ for parameter, and the corresponding relations, which are of somewhat complex form, between saturation pressures and volumes (the so-called border-curve or connode) and between saturation volumes and temperatures are deduced. R. E. B.

1505. *Entropy of a Gaseous Mixture in Combustion.* **B. Brunhes.** (Journ. de Physique, 10. pp. 325–332, May, 1901.)—Has a gaseous mixture a definite entropy during explosion or combustion? The author discusses this, and shows that under certain well-defined conditions the entropy is definite and calculable. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

1506. *Increase of Resistance of Bismuth in a Magnetic Field.* **E. van Everdingen, Jr.** (Archives Néerlandaises, 5. pp. 453–466, 1900.)—The author further inquires into a hypothesis previously made by him, viz., that the number of freely moving charged particles is less in a magnetic field than outside it, pointing out that it leads to a possible explanation of the behaviour of bismuth. He identifies the particles in question with the electrons of Drude's theory, obtaining the value $8{\cdot}7 \times 10^6$ for their mean velocity. He compares the number per c.c. of these electrons in bismuth with the number of atoms, and considers the forces to which an electron is subject, explaining that by "freely moving particles" he does not mean particles unacted on by force; they are subject to the attraction of the positively charged atoms, though the great number of uncharged atoms prevents the electrons from being permanently under the control of this attraction. An electric field gives direction to the passage of the free electrons from the sphere of influence of one charged molecule to that of another, its effect in general on bound electrons being to produce a mere *disturbance* of their motion.

An examination of the influence of the forces due to induction on the excitation of the magnetic field shows it to be negligible. The solution of the equations of motion of an electron in a field of magnetic force parallel to the z axis and electric force parallel to the x axis shows that the motion is of the same form as without the electric force save for the addition of a uniform velocity parallel to the y axis, the path of the electron not being closed but cycloidal; the expression for x contains no term in which the effect of the electric force is progressive; this appears in *cos* or *sin* functions, so that after a complete revolution no displacement has taken place in the x direction; electrons, therefore, which thus move under the influence of a magnetic and electric field take as small a part in the transference of a current as electrons moving in closed paths. However, a calculation of the greatest velocity such electrons could have shows it to be much less than the mean velocity previously determined; but a similar difficulty arises from a comparison of the calculated migration velocity with that derived from the amount of the Hall-effect. Both difficulties are removed by considering that value of the mean velocity as too high, and reasons are given in support of this view. W. E. T.

DISCHARGE AND OSCILLATIONS.

1507. *Ionisation of Atmospheric Air.* **C. T. R. Wilson.** (Roy. Soc., Proc. 68. pp. 151–161, May 4, 1901.)—In his earlier experiments [Abstract No. 1025 (1900)] the author has described the behaviour of positively and negatively charged ions as nuclei on which water vapour may condense; but the question whether free ions are likely to occur under such conditions as would make the results of these experiments applicable to the explanation of atmospheric electricity was then left undecided. The experiments now described were undertaken to determine whether a certain degree of ionisation might not be a normal property of air. The principal conclusions arrived at from the first set of experiments have already been published [see Abstract No. 849 (1901)], but the present paper contains a full description of the completed experiments and of the special, and very delicate, apparatus used. The method employed was to measure the leakage through dust-free air of electricity from a charged conductor. The difficulty in such experiments is that one is apt to be misled by the leakage due to the insulating support; but the author has managed to eliminate this source of error by fixing his charged conductor to a conducting rod by means of a bead of sulphur, and keeping this conducting rod at a constant potential, equal to the initial potential of the leaking system. Thus any leakage by way of the sulphur bead can only be in such a direction as to cause the leakage through the air to be under-estimated.

In addition to the results already published and given in Abstract No. 849 (1901), the author now gives the results of experiments made on the variation of the rate of leakage with pressure. These show that the leakage is approximately proportional to the pressure; from which we might infer that it should be impossible to detect any leakage through air at really low pressures. This agrees with the observations of Crookes, who showed that in a high vacuum a pair of gold leaves could maintain their charge for months.

Experiments were also made to test whether the production of these ions in dust-free air could be traced to the influence of radiation from sources outside our atmosphere. This test was made by observing the rate of leakage in the ordinary way, and then repeating the experiments in an underground railway tunnel, and comparing the results. If such radiation existed, we should expect it to be absorbed, to some extent at least, by the rocks above the tunnel, thus giving smaller leakage underground. The experiments show no evidence of falling-off of the rate of production of ions when the vessel was underground.

The ionisation thus seems to be a property of the air itself. These ions are continually being produced in atmospheric air to the number of 20 of each kind (positively aud negatively charged) per second in each cubic centimetre.

W. C. H.

1508. *Electric Conduction in Gases.* **A. Garbasso.** (Archives des Sciences, 11. pp. 282–293, March, and 329–344, April, 1901.)—That conduction in gases is electrolytic is not a new idea; the proofs adduced in favour of it have been indirect. The nature of the process should be essentially the same at all pressures, though simpler at low pressures. The author proves that it is easy to show electrolytic phenomena even at atmospheric pressures. Sparks (8 mm.) in a glass globe (4 cm.), the air in which has access to the surface of water, give a shifting glow which shows the spectrum lines of nitrogen only, equally throughout the glow; but if the walls of the globe be damped with an aqueous solution of lithium chloride, the discharge become very bright, mostly localised at the negative pole, and showing lithium only at that pole, while the spectrum of nitrogen comes alone from the positive pole. On reversing the direction of the current, the glows become reversed. Without the presence of some water vapour the phenomenon dies out. If the inside of the globe be damped with an alcoholic solution of LiCl, carbon lines replace N lines round the anode. The spectroscope then fails to reveal the presence of nitrogen. The solvent medium thus plays some important part. In gases, as in liquid electrolytes (Bredig and Haber), hydrogen is occluded at the surface of platinum electrodes, and may be given out if the electrodes be transferred into another tube ; and the result is more marked with the cathode. The same result is shown with similar apparatus applied to liquid electrolytes. In gases, as in liquid electrolytes (Bredig and Haber), the break-up of the kathodes requires at least (1) a given difference of potential, and (2) a given density of current. Bismuth shows the break-up extremely well ; it is used in thin (1 mm.) rods cast by drawing melted bismuth up into a very thin capillary pipette of heavy glass : as the rod solidifies it expands and bursts its coating of glass. At the instant the rarefaction becomes sufficient to establish a high enough p.d. the bismuth begins to form a mirror on the glass, while at the same moment the production of kathode rays and of fluorescence begins. With kathodes of mercury there is prompt evaporation : mercury lines, very bright, soon completely replace the nitrogen lines ; the transition is slowed down if a diaphragm of earthenware 1 mm. thick be used between the electrodes, and may then take 10 to 15 minutes. If the platinum anode have had hydrogen occluded in it, and be used as a kathode, the hydrogen comes out and hydrogen lines then completely replace the mercury lines. Further experiments are described with discharge passed through cracks in glass. The break-up of kathodes does occur (Bredig and Haber *contrà*) in hydrochloric acid. The work of Wiedemann and Schmidt (Wied. Ann. lxi. 735, 1897) on the electrolysis of HCl gas gives quantitative results at first sight not in accord with Faraday's laws : the chlorine appears to be developed near the anode as well as near the kathode ; but it would seem that the conditions were such that diffusion would account for this. Direct experiment by the authors showed hydrogen lines from round the kathode, chlorine lines from round the anode, with faint hydrogen lines. In ammonia hydrogen lines are shown from round the kathode, nitrogen lines from round the anode, the tendency apparently being for the ammonia and nitrogen to mask the presence of any free hydrogen round the anode. In an ordinary vacuum tube nitrogen does not mask the presence of hydrogen. It is therefore very probable that the conduction of electricity in a gas is electrolytic ; but in any event the process is more complex than is conduction in a liquid electrolyte. A. D.

1509. *Disruptive Discharge in Electrolytes.* **A. Broca** and **Turchini.** (Comptes Rendus, 132. pp. 915–917, April 15, 1901.)—According to Maxwell's theory conductors of electricity should be opaque : while this is true in a large number of cases, electrolytes form a class in which theory and practice are discordant. For electric oscillations of a frequency a little less than a million per second, they may, however, act more like a dielectric than a conductor. An induction coil, capable of giving an arc in air of 5 cm. when driven by a strong alternating current, is joined up with a capacity so as to give a spark without blowing out the arc. A spark-gap is formed of two brass balls about 2 cm. each in diameter ; when this is immersed in oil the appearances are very similar to those obtained in air, but if a liquid conductor is run in in the place of the oil, the sparks gain tremendously in brilliancy, and small bubbles of gas are produced. When the gap is about 2 mm. wide this appearance suddenly becomes less brilliant, but the spark remains disruptive. Unless there is another spark-gap external to the electrolyte this phenomenon cannot be produced. Reasons are given in the original paper for thinking that the discharge in its most active state is disruptive.

The brass spheres forming the break in the circuit are used up much more rapidly than those in the same circuit which are surrounded by air, and this waste, as well as the brilliancy of the sparks, is still further increased by replacing the spheres by wires. It is a complex phenomenon, and in order further to elucidate it, the *rôle* played by the frequency, the conductivity, the polarisation capacity, and other elements must be investigated. Experiments on these points are now in progress; in the meantime results are given pertaining to a few of the commoner electrolytes. R. S. W.

1510. *Oscillating Sparks.* **G. A. Hemsalech.** (Comptes Rendus, 132. pp. 917–920, April 15, 1901.)—It has already been shown that the irregular form of the spark under ordinary conditions is due to the uneven distribution of the metal vapour from the electrodes [see Abstract No. 2159 (1900)]. By the insertion of a variable self-induction in the discharge circuit it is found that the form of the discharge becomes more and more regular and the initial spark feebler as the self-induction is increased, until it seems to consist entirely of metallic vapour. The regularity or otherwise of the discharge depends largely on the nature of the metallic electrodes; copper and aluminium give the most consistent results. The brilliancy of the spark depends on the last element in a marked manner, and its variation with the induction is different in the various cases. With iron, cobalt, zinc, cadmium, copper, aluminium, and lead, the intensity diminishes at first, then increases and reaches a maximum as the induction is augmented; with other metals it shows no maxima or minima, while for the particular case of magnesium a rapid diminution is observed. That the oscillations are destroyed by the introduction into the self-induction coil of an iron core is very strikingly shown. Photographs of the spark under various conditions are taken by the method described in previous papers (see Phil. Trans. Roy. Soc. t. 193. p. 190, 1899) and some of these are reproduced. The effect is due to the magnetisation of the iron and to Foucault currents, for an iron tube is quite as efficient as a solid core, while a copper tube has an appreciable though a less influence.

R. S. W.

1511. *Periodic Oscillations produced in a Continuous Arc by Alternating Currents.* **E. Koenig.** (Comptes Rendus, 132. pp. 962–963, April 22, 1901.)—A closed circuit transformer of 3 kilowatts was placed on a lighting circuit of 240 volts with a periodicity of 40. The primary coil was of 308 turns; the secondary in five sections of 17 turns each, each section giving 13 volts. In a continuous-current circuit of 120 volts was placed a resistance coil, a hand-regulated arc lamp, and a section of the transformer secondary, all in series. Directly the alternate current was sent through the primary of the transformer the light of the arc, up to then stable, showed luminous periodic oscillations, slow enough to be perceptible to the eye. When the arc was lengthened a feeble sound corresponding to 40 oscillations per second was heard; the period of the luminous oscillations was only about $\frac{1}{20}$ of a second as estimated stroboscopically. On increasing the strength of the alternating current the luminous oscillations became more marked, without, however, altering in frequency. E. C. R.

1512. *Striated Electrical Discharge.* **J. H. Jeans.** (Phil. Mag. 1. pp. 521–529, May, 1901.)—This paper forms a continuation of a former one by the same author [see Abstract No. 1069 (1900)] and deals with one of the assumptions made in that paper, investigating as to how far the results obtained will remain valid if the assumption is not complied with. J. B. H.

1513. *Absorption of Gas in a Crookes Tube.* **R. S. Willows.** (Phil. Mag. 1. pp. 503–517, April, 1901.)—The author here describes experiments undertaken to investigate the rate of absorption of gas in a Crookes tube, and the influences exerted by the nature of the gas, the size, shape, and material of the electrodes and the composition of the glass. To give some idea of the magnitude of the effects one experiment may be instanced. With a volume of 108 c.c. and a pressure of 1 mm., a current of $10{\cdot}8 \times 10^{-4}$ amperes passing for 30 minutes reduced the pressure nearly one-eleventh.

It appears from the experiments that most, if not all, of the gas absorbed, is to be accounted for by a chemical combination with the glass; that if tubes are desired in which the pressure remains constant they should be made of Jena-glass in preference to lead-glass, and of lead-glass rather than soda-glass; and finally, that in the first two cases hydrogen is absorbed to a far less extent than air or nitrogen, the last two gases showing little difference.

J. B. H.

1514. *Radiation produced by the Impact of Slowly Moving Kathode Rays.* **J. J. Thomson.** (Phil. Mag. 1. pp. 361–376, April, 1901.)—One end of a tube is made of a brass plate A, perforated with five holes placed near together; the holes are covered on the outside with very thin aluminium foil. The face of the plate inside the tube is covered with a mica disc with a hole cut in the middle to allow the electric discharge from another electrode B to have access to A. On the outside of the plate A is a metal tube containing an insulated electrode C connected to an electrometer. The metal tube and plate A are kept to earth and a discharge allowed to pass between A and B. It is then found when the discharge passes between A and B that under certain circumstances electricity leaks from C. This leakage is greater when the plate A is kathode, but this may be because the potential difference between the electrodes of the discharge tube is less than when the current is passing in the opposite direction. The rate at which C leaks is independent of the sign of its electrification, and it does not receive a charge if it is uncharged at the beginning. This shows that the gas surrounding C is ionised, and that the ionisation is similar to that produced by Röntgen rays. If the leaking disc is replaced by a photographic plate, photographs of the holes are obtained after a few minutes' exposure. There is thus outside the tube, even when the gas is at a pressure very much greater than that in ordinary Röntgen tubes, a radiation which possesses properties similar to Röntgen radiation. This radiation is produced by the discharge from an induction coil, but more regularly by the discharge from a battery. Its chief characteristic is the ease with which it is absorbed by thin layers of aluminium or air. Its origin is found to be where the negative glow hits against a solid surface, thus when the window A is kathode and the negative glow extends to the anode B, the latter is the source of the rays. If the negative glow is deflected from B by a magnetic field then the leakage from C ceases; if the tube is exhausted so that the dark space extends to B then the leakage is very small. Other tubes can be made in which the window is not an electrode, and it is then proved that the radiation producing the leakage does not come from the light of the luminous negative column. By putting the tube containing the testing disc C in between the electrodes of the discharge tube and using a movable kathode, the way in which the leakage varies with the distance from the latter can be found. The result shows that there is a rapid increase up to the junction of the dark space with the negative glow, after which there is a gradual falling off as the kathode is further removed.

The second part of the paper gives a detailed explanation, from a mathematical point of view, of the phenomena in vacuum tubes. It has been advanced by the author that the chief agent in producing ionisation is the stream of rapidly moving negative ions, and this view has been strengthened by experiments of Townsend. These ions are removed from the gas by colliding with molecules and adhering thereto. On these two suppositions as foundation, a differential equation is found, giving the electric force at different portions of the tube; and although this cannot be solved, yet there can be inferred from it the general distribution of the force, and this is found to agree with the experimental results of Skinner and Wilson. R. S. W.

1515. *Coherer Working.* **K. E. Guthe.** (Ann. der Physik, 4. 4. pp. 762–775, April, 1901.)—Examination is made of the (*a*) negative coherer action associated with the name of Bose, (*b*) the critical potential difference for various metals, by which he implies the lowest voltage which will enable a coherer to act, (*c*) resistance variations in the coherer, (*d*) effect of heating the contact points.

The work embraced under (*b*) is new and is confirmed by many observations given in this paper. For common metals its value is from 0·2 volt to 0·06 volt. P. E. S.

1516. *Action of a Coherer.* **K. E. Guthe.** (Phys. Rev. 12. pp. 245–253, April, 1901.)—Guthe and Trowbridge have shown [see Abstract No. 2209 (1900)] that in a coherer there is a certain maximum voltage, called the *critical voltage.* The author now finds (1) on trying many metals, that the product of critical voltage into atomic weight is a constant, in each of several groups; (2) that true *metallic* contact exists in the cases tried, although he looked for electrolytic contact; (3) the higher the temperature of the contact, the lower the resistance of the coherer—and the resistance rises again to the normal when the current (which causes the heating) ceases. P. E. S.

1517. *Double Refraction of Electric Waves.* **G. Pierce.** (Phil. Mag. 1. pp. 548–551, May, 1901.)—A former communication [see Phil. Mag., Feb., 1901; and Abstract No. 1105 (1901)] described experiments on measurement of refractive indices for electric waves of several doubly refractive media, viz., various woods. These media were also doubly absorptive. In the present paper the question is examined as to whether, on Maxwell's theory, the double absorption is sufficient to account for the double refraction, and, indeed, whether both these properties can be ascribed merely to differences of conductivity of the woods along and across the grain. The mathematical treatment adopted is that used by Boltzmann in "Vorlesungen über Maxwell's Theorie," § 96 (Leipzig, 1891), though with different application. An equation is found connecting velocity and absorption of the waves in a given weakly-conducting dielectric. The medium is not supposed to be crystalline in the sense of having different dielectric constants along different axes, but merely heterogeneous in that it has different conductivities along different axes. The equation shows that in that orientation of electric force in which absorption is greatest, velocity is least, and therefore index of refraction greatest. This agrees with the results of the experiments on woods. In all the specimens tested, both index and absorption were found to be greater when the grain was parallel to the electric displacement than when it was perpendicular. The writer had not sufficient data at disposal to test the question as to whether the assumption of heterogeneous conductivity suffices to entirely explain the double refraction of electric waves by wood, though he suggests a way in which this might be done. But he draws the conclusion that heterogeneous conductivity plays an important part in the phenomenon. A. E.

1518. *Measurement of the Period of the Waves used in Wireless Telegraphy.* **C. Tissot.** (Comptes Rendus, 132. pp. 763–766, March 25, 1901.)—The method adopted was that of Feddersen, a method which has been carried to a high degree of perfection in the recent experiments of Décombe. The image of the spark is received on a rapidly rotating concave mirror, and is sent back upon a photographic plate, where it is split up and fixed. Various modifications of Décombe's arrangement have been introduced. At first the results obtained did not lend themselves to exact measurement, and scarcely indicated the oscillatory nature of the discharge, but on interposing in front of the turning mirror and on the path of the incident beam a cylindrical lens of great focal length, a great improvement was noticed, and a series of equidistant fringes of decreasing intensity was obtained on the plate. These were very distinct, and it was possible to measure their width. The indications obtained showed that the period was single and remained invariable for a given length of the antenna and the same length of spark. This period varies not only with the length of the antenna, but also with the length of spark. The periods measured were (to a first approximation) between $0·6 \times 10^{-6}$ second and $1·8 \times 10^{-6}$ second. The damping is shown by the decrease of the intensity and of the length of the images. The damping is always very marked, so that sometimes only three or four images at the most can be distinctly observed. J. J. S.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1519. *Measurements of v.* **H. Abraham.** (International Physical Congress at Paris, Report, 2. pp. 247–267, 1900.)—An account is given of some of the most important experimental methods recently employed for the determination of the number v, the ratio between the electromagnetic and the electrostatic unit of quantity of electricity. The mean of the seven measurements which are considered the most accurate is—

$$v = 3·0001 \times 10^{10}.$$

J. J. S.

1520. *Hall-Effect in Flames.* **E. Marx.** (Phys. Zeitschr. 2. pp. 412–413; Discussion, pp. 413–414, April 6, 1901. Paper read before the 72nd Naturforscherversammlung at Aachen.)—Let $\frac{\pi}{x}$ = primary potential gradient; H = strength of magnetic field; $\frac{c}{z}$ = potential gradient of Hall-effect; u, v = mobilities of positive and negative ions; theoretical investigations have shown that these quantities are connected by the relation—

$$\frac{c}{z}\Big/\frac{\pi}{x} = \frac{u-v}{2}.\mathrm{H}.$$

This formula cannot be tested by means of aqueous solutions owing to the extreme smallness of the Hall-effect in this case. In gases, too, owing to our ignorance of the way in which u and v depend on the potential gradient, a quantitative test is only feasible for very small gradients, in which case the Hall-effect again becomes too small to be accurately measured. These difficulties have been surmounted by the author by experimenting with the glowing gases in flames, because in this case, owing to the high temperature and consequent large internal friction, direct proportionality between ionic velocity and gradient can be legitimately expected as far as 100 volts per centimetre. Moreover, by spraying salt solutions into the flame, the effects for many different salts can be determined. For experimental details the author refers to a previour paper [Abstract No. 2211 (1900)]. The experimental results show that the quantity $\frac{\frac{e}{z}}{\frac{\pi}{x}} \Big/ \mathrm{H}$ is independent of variations in the strength of the magnetic field, potential gradient, and distance between the electrodes, as predicted by the convective theory.

The results also indicate that the velocity of the positive carrier in the unsprayed flame is considerably smaller than that of the positive ion in flames coloured by the salts of the alkaline metals.

In comparing $\frac{e}{z} \Big/ \frac{\pi}{x}$ with $\frac{u-v}{2}\mathrm{H}$, a correction has to be introduced owing to the acceleration of the ions. This correction is very difficult to make, and can only be applied by employing very small primary gradients and very delicate measuring instruments. When the correction is made, it is found that there is agreement so far as order of magnitude is concerned.

The paper is followed by a discussion between Quincke and Marx, which does not appear to have brought out any new or important point. F. G. D.

1521. *Electrocapillarity of Organic Compounds in Aqueous Solution.* **Gouy.** (Comptes Rendus, 132. pp. 822–824, April 1, 1901.)—The compounds examined by the author are methyl, ethyl, propyl, allyl and amyl alcohols, aldehyde, acetone, glycerine, erythrite, glucose, saccharose, lactose, phenol, pyrogallol, resorcinol, hydroquinone, acetamide, asparagine, caffeine and amygdaline, the strengths of the solutions varying from a gramme-molecule per litre to the one-thousandth of that value. To study the electrocapillarity curve throughout its whole extent it is necessary to use as solvent a dilute solution of an electrolyte, that used by the author being a centinormal sodium sulphate solution. A table is given containing for the compounds named above the values of δ, or 1,000 $(\mathrm{H} - \mathrm{H}')/\mathrm{H}$, where H is the maximum height of the column of the capillary electrometer of the sodium sulphate solution, and H′ the maximum height after the addition of the organic compound. It has already been found that δ is independent of the actual electrolyte employed, provided that it is in dilute solution, is inactive by itself and has no chemical action on the substance examined. The results show that some organic compounds, which conduct only slightly or not at all, produce quite appreciable electrocapillary effects which are often more considerable than those of the most active electrolytes. In some cases, more especially with very dilute solutions of extremely active bodies, such as caffeine and amygdaline are found to be, electrocapillary viscosity is exhibited, that is, the value of H′ diminishes to a final value. The new physico-chemical constant δ has very different values for different compounds, even for isomerides, and the way in which it varies with the dilution is very characteristic. T. H. P.

1522. *Electric Conductivity of thin Metallic Films.* **J. J. Thomson.** (Cambridge Phil. Soc., Proc. 11. pp. 120–122, April 22, 1901.)—In the electronic theory of electric conduction in metals the conductivity is expressed in terms of the mean free path of the electron. The mean free path calculated for bismuth is of the order 10^{-4} or 10^{-5} cm., so it is possible to obtain metallic films of less thickness than the mean free path in an unlimited mass of metal. The expression for the mean free path in a film of thickness d is—

$$\lambda' = d\left\{\tfrac{3}{4} + \tfrac{1}{2}\log\frac{\lambda}{d}\right\},$$

where λ is the mean free path in the unlimited mass. The specific resistance ought therefore to be a function of the thickness of the film. Experiments show that the electrical properties of thin films are qualitatively in accordance with the theory, but further experiments are needed before anything can be said as to the numerical agreement. J. B. H.

1523. *Influence of Wave-form on Ammeters and Voltmeters.* **G. Benischke.** (Elektrotechn. Zeitschr. 22. pp. 301–302, April 4, 1901.)—The author has investigated the effect of three different wave-forms, a sine curve, a very flat curve, and a very peaked curve, on induction and electromagnetic ammeters and voltmeters, of the Allgemeine Elektrizitäts-Gesellschaft's type. The induction instruments show no difference at all in their readings on different wave-forms. The electromagnetic, on the contrary, show considerable variations, amounting to 10 per cent. difference in the readings on a flat and on a peaked curve, the former giving the higher readings. The calibration curves of the instruments are given in the paper, and are in every case straight lines, that for the sine curve lying between the other two. G. H. B.

1524. *Apparent Resistance of d'Arsonval Ballistic Galvanometer.* **D. Robertson.** (Electrician, 46. pp. 901–904, April 5; and 47. pp. 17–20, April 26, 1901.)—When a d'Arsonval galvanometer used ballistically with a search coil, the motion of the galvanometer coil in its field generates an e.m.f. which is in opposition to the e.m.f. producing the throw; this has the effect of an additional resistance in the galvanometer circuit, and entails a correction, if the galvanometer constant be found from a condenser discharge, or from the steady current constant, or if found from a standard field with a different resistance in circuit to that with which the galvanometer is used. If G be the galvanometer resistance, R + G the total resistance in circuit, k the galvanometer constant, q the product of the numbers of turns in the coil into the change in lines produced by unit deflection, and of d, the deflection produced by a change of N lines in the search coil of n turns. Then—

$$\mathrm{R}d = \mathrm{N}n/k - (\mathrm{G} + q/k)d.$$

Here q/k is the correction due to the motion of the galvanometer coil, which has the effect of giving the galvanometer an apparent resistance $= \mathrm{G} + q/k$.

The author plots curves between Rd and d, for different galvanometers, the curves being slightly concave towards the origin by reason of the variation of the term q/k. When the search coil is shunted, the correction due to the damping effect of the shunt takes a similar form; if s be the shunt resistance—

$$\mathrm{R}d = \mathrm{N}n/k - (\mathrm{G} + q/k)\,\frac{\mathrm{R} + s}{s}\,d.$$

The author gives a table containing particulars of the three galvanometers; their apparent resistances, and their constants are calculated by a condenser, a standard coil, and by the steady current method. The constants given by the standard coil are from 6 per cent. to 10 per cent. higher than those given by the other methods.

The author also treats mathematically the damping effect of a shunt when used with a condenser and galvanometer, and gives curves, showing the results of his experiments with shunts of different resistances. G. H. B.

1525. *d'Arsonval Galvanometer Independent of the Field.* **P. Weiss.** (Comptes Rendus, 132. pp. 957–959, April 22, 1901.)—The author attaches to the coil of an ordinary d'Arsonval type galvanometer or ammeter a small soft-iron needle, and suspends the coil with wires exercising as little directive force on the coil as possible. The directing force is then due to the action of the permanent magnet on the iron needle, and as the deviating force also depends on the same magnetic field, the deflections are independent of any variations in the strength of the magnet. That this is so is evident from a table giving the currents required to produce deflections up to 70° with fields of 500 and of 600 gauss; the maximum difference is only ½ of 1 per cent. The deflections, however, are not exactly proportional to the current. G. H. B.

1526. *Standard Cells.* **W. Jaeger** and **S. Lindeck.** (Zeitschr. Instrumentenk. 21. pp. 33–49, Feb., and 65–80, March, 1901. Communicated by the Phys. Tech. Reichsanstalt.)—These papers contain a description of tests carried out in the Reichsanstalt on Clark and Cadmium cells, with special reference to the constancy and reliability of the Weston Cadmium cell.

The papers are divided into four sections as follows :—

1. Preparation of Cadmium cells (with 13 per cent. amalgam), and of Clark cells in 1899, and their comparison with older cells in the same year.
2. Repetition of these measurements in 1900 also extended to a temperature interval from 0° to 30° C.
3. Preparation of Cadmium cells (with 13 per cent. and 12 per cent. amalgams) at the end of 1900, and their comparison at 0° and at ordinary temperatures.
4. Summary of results and criticism of Cohen's investigations.

The comparison is summarised in the following table :—

Nr.	Time.	Wt. of Observation.	Clark 0° / Cadmium 20°.	Clark 15°. / Cadmium 20°.	Clark 0°–Clark 15°. Volt.	Observer.
1	Mar., 1896	1	1·4227	1·4066	0·0164	Jaeger, Wachsmuth
2	Jan., 1897	2	1·42277	1·40676	0·01631	„ Kahle
3	Nov., 1897	3	1·42280	1·40660	0·01650	„ „
4	Oct., 1899	3	1·42283	1·40679	0·01634	Lindeck
5	Dec., 1900	3	1·42282	1·406675	0·01645	Jaeger, Lindeck
Mean			1·42280	1·40669	0·01641	
Former Mean (1–3)			1·42277	1·40665	0·01642	

The previously determined temperature formulæ for the Clark cell and for the Weston Cadmium cell (with 14·3 per cent. amalgam and saturated solution) are found to hold as completely as could possibly be expected. The Cadmium cell with 14·3 per cent. amalgams, which show great deviations from the normal when cooled to about 0° C., may be used as standard cells above 10° C. Cadmium cells with 12 and 13 per cent. amalgams show no irregularities even when kept for a week at 0° C. Weston Cadmium cells are pre-eminently suited for standard cells. J. B. H.

1527. *New Phonographic Principle.* **W. Nernst** and **R. v. Lieben.** (Zeitschr. Elektrochem. 7. pp. 533–538, April 4, 1901.)—Sound is received on a microphone ; the currents there set up are passed through a transformer to an endless platinum band run by a motor from one drum to another. The currents enter the band on touching one drum and leave it where it touches a wooden wedge soaked in some electrolyte ; the currents then pass through the electrolyte in a vessel and leave by the other, metal, electrode. Thus the circuit is completed.

If the platinum is run fast enough, alternating polarisation will be set up on its surface. If, when this has been done, we remove the microphone and connect the system to a telephone, then we shall obtain a reproduction of the original sounds. The principle was found to be successful.

In a paper immediately following the above, **R. v. Lieben** follows up the principle by various improvements, notably that the platinum band is replaced by a strong copper disc, it having been found that the former was frequently broken in working. P. E. S.

1528. *Practical Magnetic Measurement.* **J. A. Montpellier** and **M. Aliamet.** (Électricien, 21. pp. 146–147, March 9 ; 177–179, March 23 ; 209–210, April 6 ; 225–228, April 13 ; 244–250, April 20 ; 305–307, May 18 ; 321–322, May 25 ; and 342–345, June 1, 1901.)—Magnetic measurements in practice are confined to the determination of permeability and hysteresis. For dynamo field magnets a knowledge of the permeability only is required ; for transformer iron only the hysteresis is important ; while for dynamo armatures both quantities should be known. The authors give the following figures as standards for iron of good quality : The ampere-turns per cm. to give 8,000 gauss, should be, in cast-iron, 60 ; in wrought-iron, 2 ; and in cast-steel, 1·96 ; in the two latter, 15 ampere-turns per cm. should give 15,000 gauss. As regards hysteresis, the coefficient η, should be, if possible, below 0·0016, and never above 0·002.

The methods of measuring permeability may be divided into four classes : (1) By the ballistic galvanometer ; this is not suitable for industrial use. (2) By measuring the pull. Under this head the authors describe Carpentier's permeameter, Du Bois' magnetic balance [Abstract No. 1686 (1900)], and Fischer-Hinnen's balance. The last-mentioned balance has a massive four-sided iron yoke, divided into a lower fixed part and an upper movable part ; on one side the magnetic circuit is completed by the test-rod, 80 mm. high and 500 sq. mm. in section, which is surrounded by the magnetising coil. The upper part of the yoke is supported on knife-edges projecting from the other vertical limb, the upper part being separated from the lower by a circular air-gap, the centre of which is the line of the knife-edges. A graduated bar projects horizontally from the upper part of the yoke, and carries a sliding weight which counterbalances the pull exercised by the test-rod. The balance is calibrated by placing weights on a scale pan hung in a vertical line with the centre of the test-rod, and noting the position of the sliding weight to give balance, the positions corresponding to values of the induction given by the formula $\mathsf{B} = 5{,}000\sqrt{\frac{F}{S}}$, where F is the weight in kilos, and S is the section in sq. cm. In taking a measurement the sliding weight is set to the induction required, current is passed through the magnetising coil sufficient to hold the yoke down, without any weights in the pan, and is then gradually diminished till the yoke is lifted ; the current at this moment, multiplied by a constant, gives the value of H. This is subject to a correction at low inductions for the reluctance of the yoke and air-gap. (3) Methods by measurement of the magnetic field. Under this head are described Hartmann and Braun's permeameter, in which the field is measured by the resistance of a bismuth spiral, Siemens and Halske's permeameter [Abstracts Nos. 662 and 663 (1898)], and Carpentier's torsion permeameter [Abstract No. 522 (1901)]. (4) Comparison methods, in which the permeability of the test-rod is compared with that of a standard rod of similar dimensions. As instruments of this class, the authors describe Ewing's bridge and Holden's bridge. The latter is similar to Ewing's with the difference that, whereas in Ewing's bridge balance is obtained by varying the turns of the magnetising coil on the test-rod, in Holden's it is obtained by varying the current. Balance is indicated in the same way by a magnetic needle, but in Holden's instrument this is acted on by the leakage field only, not by pole-pieces in a magnetic shunt, as in Ewing's. The current is measured by a Weston voltmeter, which can be connected by a switch to either of two resistances, one in the circuit of each magnetising coil. Commutators are provided to reverse the direction of the magnetising currents; this should be done several times after each change of current to avoid errors due to hysteresis.

Coming to hysteresis measurements, these are divided into two classes: indirect, by tracing the hysteresis curve; and direct, by measuring the energy wasted. Under the first head, the authors describe the step-by-step method of tracing the hysteresis curve, and Ewing's curve tracer; under the second head they describe the method by a wattmeter, and, very fully, Ewing's hysteresis meter, and finally the Blondel-Carpentier meter. G. H. B.

1529. *Theory of Induction Coils.* **K. R. Johnson.** (Ann. d. Physik, 3. 3. pp. 438–460, 1900; and 4. 1. pp. 137-164, Jan., 1901.)—*Part I.*—The author refers to the work of Colley, Oberbeck and Walter as giving the present state of the theory of the induction coil. Several particulars are instanced where experiment does not support theory, and it is pointed out that the theory has serious limitations by quite neglecting the change which the e.m.f. suddenly undergoes at a spark discharge. Starting from the fundamental equation

$$E_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt} + R_1 i_1,$$

for the primary, a small gap is assumed to be present in the secondary circuit for which the following equation is given :—

$$L_2 \frac{di_2}{dt} + M \frac{di_1}{dt} + R_2 i_2 = 0.$$

From these, and the equations for the currents i_1 and i_2 in primary and secondary, solutions are found for the e.m.f.'s E_1 and E_2. From an expression for E_1 it is shown that the best capacity for the primary circuit is the smallest that will prevent the spark at break. This has been verified experimentally by Walter and Mizuno. From the solution for E_2 an expression is developed for the time interval between the nth and $(n + 1)$th elementary sparks, viz. :—

$$\tau_n = \frac{C_2(E_0 - V_0)\,\epsilon^{\gamma t_n} - f(t_n, \tau_n)}{B_0 \gamma}$$

where C_2 is the capacity of the secondary, B_0 and γ constants, $E_0 - V_0$ the fall of the potential at spark, and t_n the time from the first spark. If the periodic member $f(t_n, \tau_n)$ be negligible, this equation furnishes a theoretical deduction of the law established experimentally by Moll, that the time intervals between successive elementary sparks increase in geometrical progression. As Moll's paper supports the author's theory a considerable extract is given. The above equation is reduced to the form—

$$\tau_n = \frac{L_2C_2(E_0 - V_0)}{Mi_0} \cdot \epsilon^{\gamma t_n} \times \text{a fraction nearly equal to unity,}$$

where L_2 and M are the induction coefficients of the secondary, and i_0 the current in the primary. Neglecting the fraction, the quantity—

$$\frac{L_2C_2(E_0 - V_0)}{Mi_0}$$

is the constant κ of Moll's equation $\tau_n = \kappa\epsilon^{\gamma t_n}$, and calculations are made from Moll's tables to show that when i_0 varies, κi_0 is constant. Taking λ as the spark length, and the relation of λ to spark potential as given by—

$$E_0 - V_0 = a + b\lambda,$$

Moll's numbers are again used to show that—

$$\frac{d\kappa}{d\lambda}\left(= \frac{L_2C_2}{Mi_0} \cdot b\right)$$

is constant for sparks from 0·5 to 2·5 mm. in length.

Part II.—The consideration of the current induced at make, or first induced current, leads to an expression for the e.m.f. in the secondary circuit at time t. This is used in showing that the time integrals of the induced currents at make and at break are numerically equal. It is further shown that the integral $\int_0^\infty i^2 dt$ is numerically larger for the second induced current than for the first. These results agree with experiment, viz., that a galvanometer needle gives equal throws for the two induced currents, but a dynamometer in the secondary circuit gives a greater throw for the second induced current than for the first. The latter and larger part of the paper has reference to the conditions under which spark discharge takes place. The maximum tension in the secondary must be the same for both induced currents, and the greater sparking power of the second current is due to the quicker passage of that current. By taking the maximum length of spark as proportional to the sparking potential, and to the amplitude and frequency of the current, an equation is formed, a similar one being found by substituting amplitude of e.m.f. for that of the current. Either of these equations might represent the true conditions, but two tables of experimental data taken from Moll's paper (1886) would seem to verify the first of these equations.

The secondary circuit is next altered by placing a condenser in parallel with the spark-gap, and the equations of motion are set down. As the general solution depends on an auxiliary equation of the fourth degree, single cases only are considered. It is thus found that the greater the self-induction of the spark-gap the smaller will be the potential variations produced by the current feeding the gap. This has been confirmed by Hemsalech. From the second case considered it is concluded that the local oscillations set up by the branching of the conductors are quite considerable compared with the oscillations of the main secondary current. Since the capacity and inductance of the wires are so small, the frequency is so large as to be able to cause a continuous spark resembling a silent discharge. Extracts from Moll's paper are reproduced in support of this. By giving the spark-gap a resistance value and assuming the sparks regular, the duration of the silent discharge is expressed, and in an appendix some values are calculated for duration and e.m.f. of discharge and resistance of gap. Although these vary within wide limits, they are considered by the author to confirm the assumption that the silent discharge does not consist of a continuous current, but of a series of elementary sparks which follow so closely on one another that they cannot be separated by a rotating mirror. Some results of Arrhenius also appear to add confirmation. G. E. A.

1530. *Compensating Voltmeters for the Voltage Drop in Long Feeders.* **M. B. Field.** (Inst. Elect. Engin., Journ. 30. pp. 567–591; Discussion, pp. 591–595, April, 1901.)—The author describes various methods of compensating a station voltmeter so that it will indicate the actual voltage at the various feeding-points of a two-wire network. He shows also how the voltmeter can be made to indicate the average pressure at all the feeding-points or at any desired group of feeding-points. If a multiple contact voltmeter switch is provided, then the same instrument can be used to read both the individual and the average voltages. The method involves inserting a resistance in each feeder circuit and having resistances between the bus-bars. At the maximum current the drop across the resistance in the feeder-circuit should be about two-tenths of a volt. A method is given of measuring by means of a low-tension electrostatic voltmeter the pressure at the far end of a long alternating current power-transmission line. A large and a small condenser are put in series between the mains, and the voltmeter is joined between their connecting wire and a point on a main at some distance from the station. Proofs are given of the formulæ.

In the discussion, **W. McWhirter** pointed out drawbacks to the use of Weston moving-coil meters. In his reply the author stated that any type of sensitive instrument could be used with his methods. A. R.

ALTERNATING CURRENTS AND MAGNETISM.

1531. *Method of obtaining Alternating Currents and Voltages in the Same Phase.* **A. Campbell.** (Abstract in Phys. Soc., Proc. 17. pp. 608–609, July, 1901; and Electrician, 46. p. 506, Jan. 25, 1901.)—The method is designed to produce fictitious non-inductive loads for testing energy or power meters. In the circuit containing the series coil of the instrument is a non-inductive resistance, shunted by the primary of a transformer. The secondary of the transformer is connected with the pressure coil of the instrument, and gives current in phase with the series-coil current. G. H. B.

1532. *Resonance with Alternating Currents.* **A. Russell.** (Inst. Elect. Engin., Journ. 30. pp. 596–606, April, 1901.)—It is known that if the current and e.m.f. curves are simple sine functions of the time that the power-factor is unity when there is electrical resonance. The author examines cases in which the curves are not simple sine functions, and arrives at the following conclusions:—

(1) The power-factor of a resonant circuit can only be unity when the applied potential difference wave is sine-shaped.

(2) The rise of pressure in a resonant circuit depends on the shape of the current wave. If the ohmic resistance of a choking coil, in series with a condenser, is negligible, the maximum pressure across the condenser is

infinite for a sine wave, 9·22 times the applied pressure for a parabolic wave, and 2·45 times the applied pressure for a triangular wave.

(3) If the inductance of the choking coil is varied, then the pressure across the condenser terminals is a maximum when $CL(\beta n)^2$ is unity, where C is the capacity, L the inductance, n the frequency, and β is a constant depending on the shape of the current wave. The minimum value of β is 2π, when the wave is sine-shaped.

(4) If the choking coil is in parallel with a variable condenser, then the current in the main is a minimum when $CL(\alpha n)^2$ is unity, where α is a constant depending on the shape of the potential difference wave. When this wave is sine-shaped, α has a minimum value of 2π.

(5) A condenser and choking coil whose magnitudes are connected by the relation

$$CL(2\pi n)^2 = 1$$

can be used as follows to test how much the applied potential difference wave varies from the sine shape :—

Connect them in parallel and let the current in the main be C, in the condenser C_1, and in the choking coil C_2. Then the smaller the ratio of C to either C_1 or C_2, the more nearly does the form of the wave approach the sine shape.

(6) If the condenser and choking coil be connected in series, and if $CL(2\pi n)^2$ equals unity, then if the voltage, V_2, across the choking coil equals the voltage, V_1, across the condenser, the current wave is sine-shaped. The greater the ratio of V_2 to V_1, the more distorted will be the current wave.

W. G. R.

1533. *Measuring Induction in a Yoke.* **Z. Crook.** (Amer. Journ. Sci. 11. pp. 365–368, May, 1901.)—A slot is made of ¼ mm. width in the yoke of a bar-and-yoke apparatus. Then by suddenly pulling out a fine coil in the slot connected to a galvanometer, a measure can be obtained of the induction in the yoke. Next ascertain by experiment the leakage flux for the yoke, and correcting for this, find the induction in the bar whose permeability is required. By this method the bar need not be divided, as in the usual method. P. E. S.

1534. *Magnetic Properties of Cast Iron containing Aluminium.* **A. Schweitzer.** (Elektrotechn. Zeitschr. 22. p. 363, April 25, 1901.)—Four specimens, containing from 0 to 2·45 per cent. aluminium, were tested. The latter percentage (with $H = 20$) reduced B from 4,420 to 2,170, and (with $H = 60$) from 8,000 to 5,230. The hysteresis loss, in ergs per c.c. per cycle, was increased from 1,990 to 2,800 with $B = 2{,}000$, and from 12,950 to 25,370 with $B = 6{,}000$. The results are tabulated and plotted. W. H. E.

1535. *Theory of Magnetic Induction.* **J. Buchanan.** (Phil. Mag. 1. pp. 330–341, March, 1901.)—Solutions of an equation of the same form as Fourier's equation—

$$\frac{dv}{dt} = k\frac{d^2v}{dx^2} \qquad \text{.............................(1)}$$

are capable of expressing the complex results of magnetic experiments. Functions which are solutions of (1) are not only capable of satisfying the terminal conditions, but also of expressing the complex relationship of I and

H, even when affected by strain, temperature, &c. Begin by assuming an equation—

$$\frac{dI}{dH} = p\frac{d^2I}{d\theta^2}, \quad \text{......................................(2)}$$

where p is a constant and θ a quantity whose numerical value is altered by strain, change of temperature, &c. By substituting $x = \theta p^{-\frac{1}{2}}$—

$$\frac{dI}{dH} = \frac{d^2I}{dx^2} \quad \text{......................................(3)}$$

and a solution of (3) is found periodic in H. Graphs of a function derived from this solution are found to resemble magnetic curves when a suitable choice of constants is made. The closed curve may be represented by periodic functions of a continuously increasing variable if it be looked on as a single continuous curve folded back on itself.

Examples and curves are given in which various values are taken for the different constants. The author hopes that fuller investigation may lead to a more intimate knowledge of the numerical values of x, the function of the molecular condition of materials. It is possible that the numerical value of x may prove to be as much a property of the material as, for instance, its specific heat. In the case of cyclic stress in magnetic fields of great intensity, the graph reduces more and more nearly to a simple cosine curve, which is in agreement with experimental facts. G. E. A.

1536. *Effect of Magnetic Field on Resistance of thin Metallic Films.* **J. Patterson.** (Cambridge Phil. Soc., Proc. 11. pp. 118–119, April 22, 1901.)—Longden has shown that the resistance of thin metallic films, deposited on glass by means of the kathode discharge, is much greater than that calculated from the ordinary specific resistance of the metal [Abstract No. 2214 (1900)]. The author now tries the effect of a magnetic field upon the resistance of such films. Using bismuth films, of thicknesses 1×10^{-5} cm., 6×10^{-6} cm., and 4×10^{-6} cm., and fields of 26,200 and 27,500 lines per sq. cm., he finds that the change of resistance in the magnetic field is a small increase (0·27 per cent. for the thickest film, 0·01 per cent. for the thinnest), but a very much smaller increase than that of bismuth in the form of wire. The change of resistance decreases with decrease in the thickness of the film. A film of cobalt, 1·4 × 1·3 cm. and resistance 682·2 ohms, gave no change of resistance in a field of 27,500 lines per sq. cm. W. C. H.

1537. *Magnetic Properties of an Alloy of Iron and Aluminium.* **S. W. Richardson** and **S. C. Laws.** (Phil. Mag. 1. pp. 296–301, March, 1901.)—The permeability of an alloy of iron and aluminium containing 2·42 per cent. of aluminium is found to vary in a very complex manner with temperature so long as the alloy is unannealed. The curve, expressing the induction as a function of the temperature for a constant field, has three maxima between 0° and 800° C. As the alloy is repeatedly heated and cooled these maxima gradually disappear, and when properly annealed only one maximum ordinate exists. The induction also increases at all temperatures as the annealing improves. J. B. H.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1538. *Formation of Kainite.* **J. H. van't Hoff** and **W. Meyerhoffer** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 19. pp. 420–427, April 11, 1901.)—This is a continuation of a series of papers on the Stassfurt salt deposits [see Abstracts Nos. 528 and 665 (1901)]. Kainite, $MgSO_4 . KCl . 3H_2O$, is formed at 25° from solutions saturated with magnesium sulphate and potassium chloride. The conditions of its existence in the presence of various saline mixtures have been determined and are represented diagrammatically. N. L.

1539. *Vapour-Pressure of Binary Mixtures.* **P. Duhem.** (Zeitschr. Phys. Chem. 36. pp. 605–606, April 2, 1901.)—Kohnstamm's claim [see Abstract No. 936 (1901)] of priority for van der Waals in respect of a certain formula is not justified, and the latter's theoretical result, that the vapour-pressure of a fluid mixture cannot have a maximum value for one particular concentration and a minimum value for another, is not in accordance with Caubet's observations on mixtures of methyl chloride and sulphur dioxide. This is doubtless due to the many arbitrary assumptions on which the theory of the ψ-surface rests. R. E. B.

1540. *Minimum Boiling-points and Vapour Composition.* **M. R. Ebersole.** (Journ. Phys. Chem. 5. pp. 239–255, April, 1901.)—This paper contains an investigation of the boiling-points of mixtures of benzene and acetone. The composition of the vapour-phases was ascertained by the distillation method, using specific-gravity determinations as the method of analysis. The results indicate normal behaviour.

The remainder of the paper is occupied with a valuable summary of the behaviour of pairs of liquids with respects to the following points: (*a*) Intersection of the vapour-pressure curves, (*b*) Existence of maximum or minimum boiling-points.

This was undertaken with a view to further test the theorem propounded by Bancroft, viz., that when the vapour-pressure curves intersect there will exist at some concentration a minimum boiling-point. According to the data existing at present there are five exceptions to the above rule, namely: Acetone and ethyl; alcohol propyl alcohol and ethyl acetate; benzene and carbon tetrachloride; benzene and ethyl acetate; benzene and isobutyl alcohol. In these cases the vapour-pressure curves intersect, but the boiling-point curves exhibit no minima or maxima. F. G. D.

1541. *Depression of the Freezing-point of Solutions.* **W. F. Magie.** (Phys. Rev. 12. pp. 240–244, April, 1901.)—A theoretical investigation to ascertain whether the departures of some of Loomis' results from van't Hoff's law are to be ascribed to the fact that the van't Hoff formula is only a first approximation. Using van't Hoff's method and dropping the simplifying assumptions, the author deduces a rigorous formula. The final result, however, is that van't Hoff's first approximation is sufficiently exact, and that the deviations observed by Loomis must be explained in some other way. F. G. D.

1542. *Freezing-points of Aqueous Solutions of Non-Electrolytes.* **E. H. Loomis.** (Phys. Rev. 12. pp. 220–239, April, 1901.)—This paper is a continuation of the work referred to in Abstract No. 884 (1900). After giving an account of observations on his thermometer, showing that the zero is liable to suddenly change, the author gives results obtained with aqueous solutions of milk, sugar, maltose, levulose, dulcite, acetamide, and salicine. These show that equimolecular solutions at extreme dilution have the same freezing-points, except acetamide. For a given electrolyte the molecular depression D, referred to gramme-molecules per litre of solution, changes uniformly with the concentration without maximum or minimum values; maltose is doubtful in this respect. But the molecular depression D′, referred to gramme-molecules per 1,000 grammes of solvent, is either constant for all concentrations or changes uniformly. Isomeric compounds appear to have nearly the same molecular depressions. Non-electrolytes in extreme dilution obey the law analogous to Avogadro's hypothesis, except methyl alcohol, ethyl alcohol, and acetamide. By assuming the gas laws, and throwing van't Hoff's equation into the form—

$$\frac{\Delta}{n} = \frac{RT^2}{NL},$$

in which Δ = depression, n and N are the number of gramme-molecules of solute and solvent respectively, L = latent heat of fusion of one gramme-molecule of solvent, and R, T have their usual meanings, it is seen that the value of D′ should theoretically be constant if the gas laws are obeyed. Exceptions can generally be explained by slight departure from the gas laws; but in the case of aniline the discrepancy is so considerable that it is necessary to assume association. The author's experiments tend to show that the benzene derivatives in aqueous solution form molecular aggregates. There is no evidence of ionisation of non-electrolytes in dilute solution. W. R. C.

1543. *Cryoscopic Investigations of Inorganic Solvents.* **S. Tolloczko.** (Acad. Sci. Cracovie, Bull. 1. pp. 1–22, Jan., 1901.)—The molecular depression of the freezing-point of antimony trichloride is E = 184; arsenic trichloride, when dissolved in antimony trichloride, produces a normal depression, but arsenic bromide produces a considerably larger effect, E = 266–256, and arsenic iodide gives E = 625–555; these abnormal results are probably due to interaction with the solvent and not to ionisation; potassium and mercuric chlorides also give abnormal results, but these are perhaps due to ionisation.

Antimony tribromide has a molecular depression E = 267; when dissolved in this solvent arsenic tribromide appears to be polymerised, E = 177–169, but stannic bromide and antimony chloride give normal results, whilst arsenic iodide again gives a very high value, E = 408–349, probably because of interaction with the solvent.

Arsenic bromide has a molecular depression E = 206, and normal values were obtained for solutions of arsenic iodide and stannic bromide in this solvent, but arsenic chloride gives E = 247–216, and it is suggested that ionisation may possibly occur in this case.

Stannic bromide, E = 305, gives abnormal results (E = 561 and 619) with antimony trichloride, but normal results with antimony tribromide; this is probably due, as in the similar cases mentioned above, to interchange of halogens with the solvent, and not to ionisation.

A rise of the freezing-point, due to the formation of solid solutions, occurs in the case of bismuth trichloride in antimony trichloride, bismuth tribromide in antimony tribromide, and antimony tribromide in arsenic tribromide.

The latent heat of fusion of antimony trichloride is 13·37 Cal. and of the tribromide 9·73 Cal.; the molecular depressions are hence calculated to be 177 and 274, and agree with those determined cryoscopically. [See also Abstract No. 883 (1900).] T. M. L.

1544. *Decomposition of Ammonium Nitrite.* **R. Wegscheider.** (Zeitschr. Phys. Chem. 36. pp. 543–545, April 2, 1901.)—In 1892 it was shown by Angeli and Boeris that the velocity of decomposition of ammonium nitrite into nitrogen and water is increased by the addition of an electrolyte containing either the ammonium or the nitrite ion. From this observation they concluded that the decomposition occurs only among the non-ionised molecules of the nitrite, the ions taking no part in the reaction. The author shows, however, that the facts are equally well explained on the assumption of an ionic reaction expressed by the equation: $NH_4 + NO_2 = N_2 + 2H_2O$. Thus if V is the volume of solution containing one gramme-molecule of ammonium nitrite and α the degree of dissociation of the salt, the velocity of the decomposition on the assumption that the ions react will be $k\alpha^2/V^2$, k being a constant. If now the volume V contain, besides a gramme-molecule of ammonium nitrite, a certain quantity of either another ammonium salt or another nitrite, yielding a proportion of NH_4 or NO_2 ions represented by β, the degree of dissociation α will be altered to some lower value α' and the velocity of reaction of the ions will be $k\alpha'(\alpha' + \beta)/V^2$. The dissociation constant has the values—

$$K = \alpha^2/(1-\alpha)V = \alpha'(\alpha' + \beta)/(1-\alpha')V \ldots\ldots\ldots\ldots\ldots(1)$$

Also, since α is greater than α',

$$(1-\alpha) < (1-\alpha') \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Multiplication of the expressions (1) and (2) gives: $\alpha^2 < \alpha'(\alpha' + \beta)$. Hence the first velocity of decomposition, $k\alpha^2/V^2$ is less than $k\alpha'(\alpha' + \beta)/V^2$, the velocity when a second salt is present. T. H. P.

1545. *Velocity and Catalysis in Non-homogeneous Systems.* **K. Drucker.** (Zeitschr. Phys. Chem. 36. pp. 693–709, April 19, 1901.)—A continuation of previous work on the subject [see Abstract No. 897 (1901)]. This paper commences with some remarks on the theory of the process of solution in general, and although the author confirms the results obtained by Bruner and Tolloczko [Abstract No. 405 (1901)] he cannot accept their conception of Noyes and Whitney's solution formula as a diffusion function as justified. It is pointed out that in Bruner and Tolloczko's experiments portions of the liquid were removed for analysis from time to time so that the volume varied, and it is shown, both theoretically and experimentally, that the so-called diffusion constant and also the solution velocity vary with the volume. Further experiments on the solution of arsenious oxide show that the influence of the anion in the case of hydrochloric and sulphuric acids is only secondary. Hydroxyl ions exert a much stronger catalytic action than hydrogen ions, and the increase in solution velocity is approximately proportional to the square root of the concentration of the ions. Noyes and Whitney's formula does not hold for the solution of arsenious oxide in dilute sulphuric acid, the velocity of solution being, for constant concentration of the catalytic agent, independent of the concentration of the arsenious oxide up to nearly the saturation point. N. L.

1546. *Theory of Catalytic Reactions.* **H. Euler.** (Zeitschr. Phys. Chem. 36. pp. 641–663, April 19, 1901; from the Öfversigt af K. Svenska Vetenskaps-

Akad., Förhandl., No. 4, 1899.)—In this paper a large amount of scattered experimental material is discussed in the light of the author's theoretical views. These views may be stated briefly as follows :—

(*a*) *All* chemical reactions occur between ions. (*b*) Catalytic increase of a reaction-velocity may always be traced to an *increase* in the number of the ions taking part in the reaction. (*c*) In all actual chemical reactions the total amount of available free energy cannot be obtained in the form of useful mechanical work outside the system owing to frictional and polarisation phenomena. The effect of a catalyser is to increase in a given time that portion of the available free energy which can be obtained as mechanical work.

The discussion is concerned chiefly with the catalytic acceleration of esterification, saponification, and inversion. F. G. D

1547. *Ionisation: Reply to Arrhenius, Kohnstamm, Cohen, and Noyes.* **W. Nernst.** (Zeitschr. Phys. Chem. 36. pp. 596–604, April 2, 1901.)—In reply to Arrhenius [see Abstract No. 908 (1901)] Nernst asserts that the formula for the p.d. of a concentration cell recently given by Arrhenius and that given originally by himself are *equally valid* from a thermodynamical point of view and hold good provided the "gas" laws apply. He also points out that one can be deduced from the other if Ostwald's "dilution" formula holds good—a fact which has been already pointed out.

The replies to Kohnstamm, Cohen, and Noyes concern small matters of detail for which reference must be made to the original paper. F. G. D.

1548. *Decrease of Osmotic Pressure by Ion-charges.* **V. v. Türin.** (Zeitschr. Phys. Chem. 36. pp. 524–528, April 2, 1901.)—The electrostatic energy of a system of spherical drops of an electrolyte is proportional to the total surface, and its magnitude per unit area is given by the equation—

$$W = 0{\cdot}4\,Q\,.\,K\,.\,D^{-1}\,.\,q,$$

where Q is the total charge on unit mass of hydrogen-ions (96,537 coulombs), K the concentration of the solution in gram-equivalents per c.c., D its dielectric capacity, and q the charge on an ion. For an aqueous solution the electrostatic energy per unit area is given in ergs by the equation—

$$w = 1{\cdot}5 \times 10^9 k\,.\,q,$$

where k is the concentration in gram-equivalents per litre, and q the charge on an ion. [See also Abstract No. 2284 (1900).] T. M. L.

1549. *E.M.F. and Osmotic Pressure.* **R. A. Lehfeldt.** (Phys. Soc., Proc. 17. pp. 577–604; Discussion, p. 605, July, 1901; and Phil. Mag. 1. pp. 377–403, April, 1901.)—Assuming the validity of the simple gas laws for solutions the author deduces thermodynamically the following equation :—

$$E = \frac{RT(1-x)}{r\epsilon}\left((n-1)(\gamma_2-\gamma_1) + \int_{C_1}^{C_2}\{1+(n-1)\gamma\}\frac{dC}{C}\right)$$

where $E =$ e.m.f. of a concentration-cell, in which the solutions have concentrations C_1 and C_2,
$r =$ least common multiple of valencies of the ions,
$n =$ number of ions formed from a molecule of electrolyte,
$x =$ transference ratio for the kation,
$\gamma =$ degree of ionisation.

The conclusion is drawn from this that the e.m.f. depends not on the osmotic pressure of the *metallic* ions only, but on that of the solution as a whole.

If the gas laws be not assumed, then deviations from Boyle's law may be allowed for by writing for the osmotic pressure $P = RTiC$, where i is no longer identical with $1 + (n - 1)\gamma$; in this case the previous equation becomes—

$$E = \frac{RT(1 - x)}{re}\left(i_2 - i_1 + \int_{C_1}^{C_2} \frac{i\,dC}{C}\right).$$

Applying this equation to the case of zinc in zinc chloride solution, it is found that the electrolytic solution-pressure of zinc need only be regarded as of the order of magnitude of 20,000 atmospheres instead of the value 10^{19} atmospheres required by Nernst's theory.

Measurements are given of the e.m.f.'s of concentration-cells with zinc electrodes, containing (*a*) zinc chloride, (*b*) zinc sulphate solutions. These measurements are employed to determine the osmotic pressures of the concentrated solutions and the corresponding values of PV.

Very considerable deviations from Boyle's law are found to occur. F. G. D.

1550. *E.M.F. and Osmotic Pressure.* **F. Krüger.** (Zeitschr. Phys. Chem. 36. pp. 87–90, Jan. 22, 1901.)—In reply to Lehfeldt, the author points out that Nernst's formula for the e.m.f. of a concentration-cell can be deduced from the thermodynamical formula given by Lehfeldt by *assuming the validity of the Ostwald dilution-law.* From this he concludes that Lehfeldt's formula is not new. F. G. D.

1551. *Electrocapillary Phenomena.* **W. Palmaer.** (Zeitschr. Phys. Chem. 36. pp. 664–680, April 19, 1901.)—A discussion of the theories of Helmholtz, Warburg, and Nernst.

(*a*) Helmholtz's theory, in which the mercury electrode is regarded as acting as an insulating condenser surface and in which no actual separation of ions is supposed to occur, offers no explanation of the "natural" p.d. between mercury and ordinary sulphuric acid. Moreover, the Helmholtz explanation of the p.d. between a "dropping" mercury electrode and a quiescent mercury electrode in the same solution requires the assumption that a not inconsiderable period is necessary for the development of the natural p.d. between a freshly formed mercury surface and the sulphuric acid solution. There is no incontestable evidence for this, as the facts brought forward by König can be very simply explained by Nernst's theory.

(*b*) Warburg's theory was an important advance, as it recognised the fact that ordinary sulphuric acid contains dissolved oxygen, and soon dissolves some mercury, so that there are mercury ions concerned in the phenomena. Hence when an external p.d. is applied to a Lippmann capillary electrometer, a true conduction current ensues whereby the concentration of the mercury ions at one electrode is increased and at the other diminished, and so a compensating (reverse) e.m.f. produced. In order to explain the high p.d. (0·8 volt) between a dropping and a quiescent mercury electrode in a sulphuric acid solution, Warburg was forced to assume that mercury had the power of "condensing" a concentrated film at its interface with the solution. This hypothesis, however, will not answer the purpose, as it would require the presence in the condensed layer of at least $2 \cdot 10^{14}$ kilograms of mercury per cubic millimetre.

(*c*) Nernst's theory is simply an application of the theory of solution-pressure to the particular case of mercury. It offers an explanation of the polarisation of the Lippmann electrometer similar to that given by Warburg. It supplies, however, a satisfactory explanation of the high p.d. obtained with the dropping electrode, for on account of the low electrolytic solution-pressure of mercury, mercury ions are deposited on every fresh surface, and so the concentration of the mercury ions at the dropping electrode is continually diminished. This process is only compensated by disturbing effects such as convection, stirring of the liquid, &c., and under suitable conditions may proceed very far.

The paper contains further a discussion of G. Meyer's extension of Warburg's "condensation" theory to the case of dropping electrodes in which amalgams are used, wherein the author endeavours to prove that the phenomena can be explained by means of Nernst's theory without the hypothesis introduced by Meyer. The reader must be referred to the original paper for the details of this discussion.

In conclusion it is pointed out that although the majority of the observed phenomena can be explained by an application of Nernst's general theory without the introduction of new hypotheses, nevertheless there remain several outstanding facts for which there exists as yet no satisfactory explanation. Chief among these is the unsymmetrical character of the relationship between surface tension and applied p.d., as observed in the Lippmann capillary electrometer. F. G. D.

1552. *Iron and Steel from the Standpoint of the Phase-Rule.* **F. Osmond.** (Metallographist, 4. pp. 150–161, April, 1901 ; from the Bulletin de la Société d'Encouragement, Nov. 30, 1900.)—This and the following Abstract form a criticism of Roozeboom's paper of the same title [Abstract No. 2275 (1900)].

A sample of iron containing not more than 2 per cent. of carbon exists at high temperatures exclusively in the form of mixed crystals of γ-iron and carbon, but when slowly cooled it is converted into a mixture of *ferrite* or α-iron and *cementite* (Fe_3C), the iron passing into the magnetic modification which is stable at ordinary temperatures, and the whole of the carbon being converted into carbide. By rapid cooling the forms stable at high temperatures are more or less preserved, and it is now suggested that *austenite*, which occurs as a constituent of chilled steel, is probably identical with the mixed crystals which are stable at high temperatures ; *martensite*, which is usually regarded as identical with the mixed crystals of γ-iron and carbon, appears to represent the first stage in the transformation of austenite into ferrite-cementite ; it is produced by quenching in cold water small samples of iron containing not more than 1·10 per cent. of carbon, and corresponds to the maximum of hardness for the given content of carbon. *Troostite* is a transition form approaching more nearly to that stable at ordinary temperatures ; it is produced by a mild quenching (in oil or boiling water) of small pieces of steel, by sudden cooling during recalescence, or by a mild tempering of martensite. *Sorbite* approaches still more nearly to the condition which is stable at ordinary temperatures, and may perhaps be regarded as an imperfectly separated mixture of ferrite and cementite ; it is produced by cooling small samples in air, by quenching in cold water towards the end of recalescence, by quenching in molten lead, or by tempering martensite to a blue colour. No sharp line of demarcation can be drawn between troostite and sorbite, and it is probable that they do not represent a condition of equilibrium, and are therefore not amenable to the phase-rule ; Roozeboom is therefore probably right in limiting his treatment to α-, β-, and γ-iron, together with graphite, cementite, and the mixed crystals of γ-iron and carbon which he calls martensite, but which more closely resemble austenite.

Below 1,000° the graphite which separates from an iron containing between 2 per cent. and 6·6 per cent. of carbon should be converted into cementite, whilst above this temperature the reverse change should take place ; in confirmation of this an experiment is quoted, in which more than half of the carbon (3·85 per cent., all combined) of a sample of cast iron was converted into graphite by heating to 1,030°, whilst, on the other hand, a soft cementation steel containing 1·38 per cent. graphite and only 0·24 per cent. of combined carbon was converted into a hard steel with a large proportion of combined carbon by heating to 780°–950°. T. M. L.

1553. *Iron and Steel from the Standpoint of the Phase-Rule.* **H. le Chatelier.** (Metallographist, 4. pp. 161–170, April, 1901 ; from the Bulletin de la Société d'Encouragement, Nov. 30, 1900.)—No less than eleven different phases are possible in a mixture of iron and carbon, but by the phase-rule it is shown that, neglecting the gaseous phase, (1) four phases can never exist together in equilibrium, and if four phases are detected the system is still undergoing change ; (2) three phases can exist together only at a definite temperature and with a definite composition of each of the three phases, the relative proportions of which may alone vary ; (3) two phases can exist together at any temperature, but the composition of these phases is dependent on the temperature and can only be made to vary by changing the temperature ; (4) one phase may exist at any temperature, and the composition of the phase can also be varied arbitrarily. By these rules the determination of the equilibrium between the eleven possible phases is greatly simplified, and becomes a practicable problem.

It is shown that the curve representing the melting-point of mixtures of iron and carbon shows a slight break at 2·25 per cent. of carbon and a temperature of 1,275° ; if this can be clearly established it is of considerable importance as showing that two different solid phases separate from the liquid at different temperatures, and these would probably be identical with austenite and martensite ; this is thought to be more probable than Osmond's suggestion that martensite is a partially changed austenite.

When steel containing 0·9 per cent. of carbon is heated to the recalescence-point a *double* change occurs, which is made manifest by a sudden contraction in volume followed by an equal expansion. When quenched at the beginning of the contraction the steel was found to consist entirely of pearlite (a eutectic mixture of ferrite and cementite representing the stable equilibrium at ordinary temperatures) ; quenched at the maximum contraction it consisted almost entirely of troostite with a little pearlite and martensite ; quenched at the end of the expansion it consisted entirely of martensite. This shows that the change is probably that represented by the scheme :—pearlite ⟶ troostite ⟶ martensite, and suggests that troostite is a modification which is stable within a very narrow range of temperature near the recalescence-point.

T. M. L.

1554. *Amphoteric Electrolytes and Lactonic Salts.* **K. Winkelblech.** (Zeitschr. Phys. Chem. 36. pp. 546–595, April 2, 1901.)—The author first explains the meaning of the term "amphoteric" as applied to electrolytes, and gives the various classes of compounds to which the name is applied together with their reactions. Prominent among these compounds, which function both as acids and bases, are the amino-acids. The determination of the acidity and basicity constants of such substances may be carried out by measuring the extent to which the salts formed by them with strong acids and with strong bases are hydrolysed. To this end the author uses partly the determination of the change of electrical conductivity produced by adding an amphoteric electrolyte to a solution either of hydrochloric acid or of sodium hydroxide, and partly the measurement of the catalytic influence of the free hydrogen or hydroxyl ions on the decomposition of ethyl acetate. These methods are applied to the investigation of betaïne, sarcosine, leucine, glycocoll, alanine, taurine, asparagine, *o-*, *m-* and *p-* amino-benzoic acids, aspartic acid, hippuric acid, sulphanilic acid, amino-sulphonic acid, methyl orange, hydroxylamine, hydrocyanic acid and urea. The results obtained do not point to any simple relation between the acidic and basic functions of the groups in any one molecule, but in some series of analogous compounds the acidity and basicity are found to increase together. This is the case with the aminobenzoic acids, and with these also the greatest diminution in the acidic and basic functions occurs when the amino- and carboxyl-groups are in the ortho-position. Simultaneous increase of acidity of basicity also obtains with the series, alanine, glycocoll, leucine, sarcosine, and betaïne. For glycocoll, sarcosine, and betaïne the acidity decreases more rapidly than the basicity, whilst for the aminobenzoic acids the reverse holds. With regard to the amino-acids, which are usually regarded as having a lactonic or anhydride structure, the results indicate that their aqueous solutions contain for the most part non-dissociated hydrolysed molecules, due to the water acting as a weak base or acid and combining with the acidic or basic group of the amino-acid. T. H. P.

1555. *New Method for the Measurement of Ionic Velocities.* **B. D. Steele.** (Chem. Soc., Journ. 79. and 80. pp. 414–429, April, 1901.)—The method is a modification of that introduced by Lodge (B.A. Report, 1886, p. 395) in which the velocity of an ion is measured directly by means of the movement of the boundary between a colourless and two coloured salts in a gelatinised electrolyte during the passage of a current. The use of gelatine is largely avoided by employing vertical tubes, and it has been found to be possible under certain conditions to observe the boundary between colourless solutions by means of slight differences in density and refractive power, so that the use of a coloured solution is also rendered unnecessary.

In the case of magnesium sulphate concordant results were obtained by noticing the velocity of motion of the boundary in the systems, $CuSO_4$ | $MgSO_4$ | $K_2C_2O_4$, $CuSO_4$ | $MgSO_4$ | $NaC_2H_3O_2$, and $CdSO_4$ | $MgSO_4$ | $NaC_2H_3O_2$, but the ratio of the anion and kation velocities differed from the value obtained by Masson in gelatinised solutions, showing that the gelatine affects the two ions unequally. The chlorides and bromides of sodium and potassium were examined in a similar manner, using lithium chloride and sodium acetate as indicator solutions. In the case of these salts the values obtained differed only slightly from those observed by Masson in gelatinised solutions.

For details of the apparatus used and the conditions necessary for securing well-defined boundaries reference must be made to the original paper.

T. M. L.

1556. *Electrolytic Phenomena in Secondary Circuits of Induction Coils.* **K. R. Johnson.** (Ann. d. Physik, 3. 4. pp. 744–748, 1900.)—A water voltameter in which the electrodes are platinum points is put into the secondary circuit of an induction coil, and the make and break is done by hand. Gas bubbles are observed to stream from each electrode at break, but none at make. This electrolysis is put down to electric waves arising at break. In another experiment in which the interrupter of the coil is used, the gases given off have volumes in the ratio 2 to 1. But these gases explode, and it is found on absorbing the oxygen that the volumes are each reduced by one-third, the inference being that each amount contained equivalent volumes of H_2 and O_2. The difference in the amounts given off at the two electrodes is ascribed to asymmetry of the inductors, and can be eliminated by adding a suitable resistance to the primary. By varying the capacity of the condenser in the primary circuit it is shown that the amount of gas given off per unit of time is inversely proportional to $\sqrt{\text{capacity of primary condenser}}$. The actions of Holtz's machine and the induction coil are similar, the amount of gas set free being very much greater in the case of the coil. G. E. A.

1557. *Electrolytic Purification of Mercury.* **W. McA. Johnson.** (Elect. World and Engineer, 37. p. 684, April 20, 1901.)—This paper gives an account of some experiments made with a view to the removal of the small impurities present in ordinary commercial mercury. About 1 kilogramme of mercury was placed in a crystallising dish and covered with 500 c.c. of a solution of KNO_3 (4 per cent.) and HNO_3 (17 per cent.). The electrical connection was made to the mercury by means of a platinum wire sealed into a glass tube passing through the solution. The kathodes were two carbon rods. A careful arrangement of the electrical circuit was employed to regulate the current, and it was found that a voltage of from 0·75 to 1·0 volt could be employed whereby the Sn, Cd, Pb, Cu, &c., were carried into solution with very little mercury. The solution was changed several times, and after six hours' electrolysis the mercury was very mobile and left no discolouration on porcelain. No analyses, however, are given. Low-current density gives the best results. The author thinks that this method may be of service where a steady current is available as an alternative to the method of dropping finely divided mercury through a long tube filled with HNO_3.

J. L. F. V.

1558. *Commercial Electrolysis of Water.* **W. Dürer.** (Elektrochem. Zeitschr. 8. pp. 1–2, April, 1901.)—The author discusses some of the difficulties met with in the electrolysis of water for industrial purposes. The danger of producing detonating gas when using metallic diaphragms is pointed out, and reference is made to Bassani's automatic attachment for checking the specific gravity of the hydrogen gas as it issues from the electrolytic apparatus. The absorption of carbonic acid gas from the air by the caustic soda solution used as electrolyte in the cell is a second difficulty. This is overcome by working the cell at a fairly high temperature, or by covering the electrolyte with a layer of oil. As regards the use of the electrolytic gases, it is pointed out that hydrogen prepared in this way is more suitable for military balloons than hydrogen prepared by acting on iron with sulphuric acid, since it is purer than the latter. The weight of pure hydrogen is 89 grms. per cubic metre. The corresponding figures for electrolytic and for chemical hydrogen are 107 and 160 grms. respectively.

Hydrogen gas produced by electrolysis of water is odourless, and on this account it is difficult to detect leaks in the apparatus or gas-holders. In order

to overcome this objection to the gas it is necessary to add a little mercaptan to each vessel containing the gas. Reference is made to the installation of an apparatus for the electrolysis of water at Rome. [See Abstract No. 539 (1901).]
J. B. C. K.

REFERENCES.

1559. *Estimation of Metals by Electrolysis.* **C. Nathan.** (Electro-Chemist, 1. pp. 46–47, Feb.; 59–60, March; 85–86, April, 1901.)—This paper comprises a brief historical account of the introduction of electrolytic methods into chemical analysis, a description of the apparatus in general use and of the principles involved, and brief directions for the estimation of the more important metals and alloys. N. L.

1560. *Ionisation of an Electrolyte in a Mixture of Electrolytes.* **Y. Osaka.** (Zeitschr. Phys. Chem. 36. pp. 539–542, April 2, 1901.)—Let d = degree of ionisation of the electrolyte in question, K = its dissociation constant, T = total number of all the anions or kations present. Then for binary electrolytes obeying the law of mass action—

$$d = \frac{K}{K+T}$$

This theorem has been already employed by Arrhenius. The author directs attention to it, and gives a proof of it in the general case of n binary electrolytes. F. G. D.

1561. *Annual Report on Atomic Weights.* **F. W. Clarke.** (Chem. News, 83. pp. 161–162, April 4; and 169–170, April 12, 1901. From the Journal of the American Chemical Society, 23. No. 2.)

1562. *Reducing Power of Calcium Carbide.* **Fr. v. Kügelgen.** (Zeitschr. Elektrochem. 7. pp. 541–550, April 11; 557–568, April 18; and pp. 573–580, April 25, 1901.)

1563. *Physico-Chemical Studies of Tin. IV.* **E. Cohen.** (Zeitschr. Phys. Chem. 36. pp. 513–516, April 2, 1901.)—Quotations are given from Aristotle, Plutarch, and Montaigne, showing that the crumbling of white tin into grey tin during extreme cold has been known from classical times. [See further, Abstract No. 529 (1901).]
T. M. L.

1564. *Theory of Electrolysis.* **G. Platner.** (Elektrochem. Zeitschr. 8. pp. 8–11, April, 1901.)—A theoretical paper on the same lines as some previous papers by the author [see Abstract No. 1378 (1898), and No. 1214 (1899)]. The phenomena of electrolysis are not considered to be fully explained by the theory of electrolytic dissociation. Stress is laid on the unity of electricity, hydrolytic dissociation, and the function of the solvent in electrolysis. A satisfactory solution of the problems involved is to be sought in a more intimate knowledge of chemical and molecular forces. N. L.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

1565. *Engines for the Brooklyn Edison Plant.* (Amer. Electn. 13. pp. 108–110, March, 1901.)—Each engine is vertical cross-compound with Corliss gear, having cylinders 46 and 86 inches by 60 inches stroke. Its most economical speed is 75 r.p.m., developing 3,750 h.p., but it will run up to 7,500 with safety. The h.p. cylinder clearance is 3 per cent. and the l.p. 2 per cent. Steam jackets are not used, as the Westinghouse Company find that after a piston speed of 600 feet per minute they are of little or no use. A reheater, however, is employed in the receiver having a surface of 1,500 square feet. Higher values of reheating surface have been advocated by some builders, but this proportion gives very good results and has certain distinct advantages. The steam passing through the engine is passed through the inside of the heater tubes, and boiler steam is used on the outside. The connecting rods are 5½ crank-lengths. The shaft is hollow, 39 inches diameter within the flywheel, 34 inches in the bearings, and weighs 75 tons without the centre. The construction of the flywheel is novel; the segments and arms are of cast steel and the centre of wrought iron. There are five centre rim segments, each cast in one piece, with two of the arms; this effectually prevents any two joints coming diametrically opposite to one another. On either side of the centre segments are disposed five plates linked together, and so arranged as to break joints with the centre segments to which they are riveted. This form of construction practically results in three flywheels, each self-supporting as to centrifugal force.

The most novel feature of this engine is the safety stop arrangement, which consists of a small weight pivoted in the crank cheek and held in position by a spring. When the speed exceeds a certain limit the weight flies out, overcomes the action of the spring, and hits a small lever. This lever works a three-way cock that admits steam to a cylinder controlling a valve in the main steam-pipe. When steam is admitted to this cylinder it closes the valve, shuts off the steam, and so stops the engine. Steam can also be admitted by hand to this cylinder from the engine platform, thus stopping the engine. Forced lubrication is used throughout the engine.

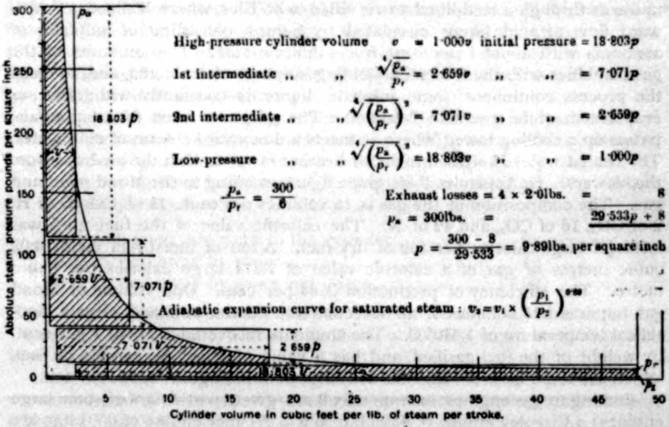
L. S. R.

1566. *Proportions of Cylinders for Multiple-Expansion Engines.* **A. Hanssen.** (Mech. Eng. 7. pp. 602–605, April 27, 1901. Paper read before the Civil and Mechanical Engineers' Society, April 4, 1901.)—Although the correct design of cylinders and valve gear cannot make an engine economical if other conditions are unfavourable, it is important to have the work done in each of the cylinders equal, especially where each cylinder operates a separate crank. As an example of the often under-estimated or almost neglected effects of radiation in causing condensation in the cylinders, the author quotes an instance where the steam consumption per i.h.p.-hour was diminished by 49 per cent. simply by increasing the thickness of lagging, on all the steam-heated surfaces, from 1 inch to 3 inches.

Although sufficient initial super-heat to allow of the steam being above the saturation temperature at release is generally not permissible, adiabatic expansion should at all events be striven for. The author gives a semi-graphical method of finding the cylinder proportions from the curve of adiabatic expansion. If n be the number of cylinders, p_a the initial pressure, and p_r that at release, the diagram is divided vertically into n parts in the proportion—

$$1\,;\ \left(\frac{p_a}{p_r}\right)^{\frac{1}{n}};\ \left(\frac{p_a}{p_r}\right)^{\frac{2}{n}};\ .\ .\ .\ \left(\frac{p_a}{p_r}\right)^{\frac{n-1}{n}},$$

and horizontally into n parts, each part inversely proportional to the range in pressure of the corresponding part of the diagram. There are thus obtained n rectangles of equal area approximating to the shape of the curve. The indicator diagrams contained in these n rectangles are very nearly equal in area. An example of quadruple expansion is given in the figure. This gives the proportion; the actual area of the low-pressure cylinder being given by $a = \dfrac{\text{i.h.p.} \times 33{,}000}{p_m \times \text{S}}$, where S = piston speed and p_m = total mean pressure reduced to low-pressure cylinder. H. R. C.



—Example Showing Cylinder Proportions for a Quadruple-Expansion Engine.

GAS AND OIL ENGINES.

1567. *Power Gas and Large Gas Engines.* **H. A. Humphrey.** (Inst. Mech. Engin., Proc. 1. pp. 41–118; Discussion, pp. 119–247, Jan., 1901.)—In an appendix the author gives the cost of 1 b.h.p.-hour in manufacturing works, as the mean of a large number of actual results; it varies from 0·68d. for ordinary works with fairly uniform load to 1·80d. for small works with varying load.

A description is given of the Mond gas-producer, illustrated by five diagrams and four photographs. Common bituminous slack is used as fuel, and is fed into the producer bell. On reaching the hot zone of fuel the tar is converted into a fixed gas, and the slack then descends into the body of the producer, where it is acted on by an air-blast, which has been saturated with steam at 85° C. and superheated. The steam used per ton of fuel gasified is 2½ tons; this large quantity keeps the temperature of the producer within such limits as to prevent the formation of clinkers or the destruction of the ammonia. Half a ton of steam is decomposed per ton of fuel burnt, yielding 29 per cent. by volume of hydrogen in the final gas. The hot gas and undecomposed steam, leaving the producer, pass first through a tubular regenerator in the opposite direction to the incoming blast. An exchange of heat takes place, and the blast is still further heated by passing down the annular space between the two shells of the producer. The hot gases then pass through a washer, in which they meet a water-spray thrown up by revolving dashers, and are thereby cooled to about 90° C. The gas then passes upwards through a lead-lined tower filled with tiles, where it meets a downward flow of acid liquor circulated by pumps, consisting of sulphate of ammonia with about 4 per cent. free sulphuric acid. The ammonia of the gas combines with the free acid, yielding sulphate of ammonia, and, to make the process continuous, some sulphate liquor is constantly withdrawn or evaporated, while free acid is added. The gas, now freed from ammonia, passes up a cooling tower, where it meets a downward stream of cold water. The heated water is utilised in an air-heating tower to heat the air-blast from the blowers. In Appendix 1 are given figures relating to the Mond plant and gas. The composition of the gas is, in volumes per cent., 11 of CO, 29 of H, 2 of CH_4, 16 of CO_2, and 42 of N. The calorific value of the fuel used was 6,900,000 large calories per ton of dry fuel. A ton of moist fuel yields 4·02 cubic metres of gas, of a calorific value of 1,414 large calories per cubic metre. The efficiency of production is 84 per cent. One volume of Mond gas requires 1·15 volumes of air for complete combustion, and gives a theoretical temperature of 1,610° C. The ammonia recovered is about 1 per cent. by weight of the fuel gasified, and has a value of about 8s. per ton of fuel, which at the pit costs 2s. 6d., and delivered at Winnington 6s. 9d. per ton.

Coming to gas engines, in Appendix 3 are given particulars of some large engines; a Crossley engine of 450 i.h.p. and a Premier engine of 650 i.h.p. are running day and night on Mond gas at Brunner, Mond & Co.'s works; a 700-i.h.p. Simplex engine is running on blast furnace gas at Seraing, and two 1,500-i.h.p. Westinghouse engines are being built for use with natural gas. In Appendices 4 and 14 are given full particulars of the above-mentioned Crossley and Premier gas engines, and of some large Œchelhäuser and Otto engines; these are illustrated by numerous diagrams and photographs. In Appendix 5 are given the results of tests on the Crossley and Premier engines, running with Mond gas. The Crossley engine has two cylinders, 26 inches by 36 inches stroke. Working at 314 b.h.p. at 152 r.p.m. the mechanical efficiency was 90·76 per cent., and the thermal efficiency (i.h.p.) 27·2 per cent.; the consumption of Mond gas was 60 cubic feet per i.h.p.-hour, or 72 cubic feet per b.h.p.-hour. Diagrams of the valve motion are given, and indicator diagrams, showing a maximum pressure of about 240 lbs. per square inch, with an effective pressure of 63 lbs. per square inch, and a clearance of about 26 per cent. of the working stroke; there are also given diagrams taken with a light spring, of firing cycles, and cycles taking air only, and curves are given, showing at different speeds the h.p. lost in running idle, the h.p. lost in fluid resistance when exploding, and the percentage of return stroke when the compression curve crosses the atmospheric line.

The Premier engine is a two-cylinder tandem engine with positive scavenging and water-cooled pistons; the cylinders are 28½ inches by 30 inches stroke.

The engine worked at 368 b.h.p. at 128 r.p.m. The mechanical efficiency was 81 per cent., and the thermal efficiency (i.h.p.) 30·4 per cent.; the consumption of Mond gas was 52 cubic feet per i.h.p.-hour, or 69 cubic feet per b.h.p.-hour. One i.h.p.-hour was obtained from 0·88 lb. of moist bituminous slack, containing only 62 per cent. of carbon. Indicator diagrams are given showing a maximum pressure of 325 lbs. per square inch, and an effective pressure of 108 lbs. per square inch; the amount of the clearance is 27 per cent. of the working stroke.

Appendix 6 gives the results of an official trial of a 60-n.h.p. Crossley engine coupled to a Siemens dynamo, and supplied with Mond gas. Appendix 7 is a report on the working of this engine; during 1898 and 1899 it ran during 96·6 per cent. of the whole time, at an average i.h.p. of 115, and has run for 3,300 hours without a stop. The average consumption during the two years was 67·7 cubic feet of Mond gas, or 1·055 lbs. of slack, per i.h.p.-hour, and 117·3 cubic feet or 1·82 lbs. of slack per e.h.p.-hour. Appendix 8 contains figures relating to the test of a 65-b.h.p. Westinghouse engine with natural gas, and gives indicator diagrams.

Appendix 13 gives a large number of tests with very full particulars of various Continental engines, namely, a test by Witz on a 200-h.p. Simplex engine at Seraing, and one by Hubert on a 600-h.p. engine at the same place, the engines using blast furnace gas. The heat balance-sheet given by Hubert for the 600-h.p. engine is—

Heat converted into work in the cylinder..................	28	per cent.
Heat carried away by water....................................	52	„
Heat carried away by gases and losses	20	„

Eight pages of this Appendix are occupied by brake trials conducted by Delamare, Deboutteville, and Cockerill on a 600-h.p. engine working with blast furnace gas.

Appendix 10 gives comparative figures of the cost of fuel per kw.-hour with steam and gas. Unwin's ideal estimate for continuous running made the cost 0·194d. per unit; Kennedy's ideal estimate for a central station gave 0·210d.; the average cost for eighty-three electric light stations is 0·778d.; the actual cost with Mond gas at Winnington is 0·048d. Appendix 9 contains an estimate of capital and running costs for a 20,000-h.p. central station gas plant, worked with Mond gas at various load factors.

The author made experiments on the speed variation during the strokes of the Crossley and Premier engines, by means of an electric tuning-fork tracing vibrations on a smoked drum. Diagrams are given for both engines showing, throughout the stroke, the inertia forces due to the reciprocating parts, the indicator diagram corrected for inertia, the turning moment on the crank-shaft, and the speed. In the Crossley engine, with both cylinders firing every time, the variation from the mean speed at full load was 0·094 of 1 per cent., and on the "hit and miss" system at three-quarter load it was 0·976 per cent. Curves are given showing the variation of efficiency due to variation in the gas mixture; the curves are sufficiently flat to show that governing is possible by controlling the admission of gas, instead of by the usual hit-and-miss system. Appendix 12 contains a full table of gases saturated with water vapour at different temperatures, and Appendix 11 details the precautions taken to ensure accuracy in the author's experiments.

Discussion.—**W. J. Crossley** referred to the tests of his gas engine, and explained the reasons which led him to adopt low compression. He gave indicator diagram and figures relating to a test of a 150-i.h.p. engine, which with coal gas showed a thermal efficiency of 31·8 per cent. He had given much attention to the fluid resistance of engines when missing a stroke, and had devised methods for cutting off the gas at any desired portion of the stroke, so that the piston made a slight vacuum which assisted its return. He believed that the irregular sequence of explosions in his tandem engines was the best, as it made possible a far better design of engine. He had a small Mond gas plant at his works, which ran successfully except that the sawdust in the scrubbers required very frequent changing. **J. E. Dowson** spoke on the necessity of gas holders; he thought it would not be safe to work large engines without a gas holder to check the great fluctuations of pressure caused by the suction of the piston. He supposed the reason that no gas holder was used at Winnington was that only a very small proportion of the gas generated was used in the engines, and that the large gas mains acted as a gas holder. He considered the proportion of 16 per cent. of CO_2 contained in the gas called for some improvement, and expected that if worked without sulphate recovery, the plant would not give very economical results. **A. Rollason** gave particulars of a Mond plant of 1,000 i.h.p. erected at the Premier gas-engine works, without sulphate recovery. At full load, 1 lb. of Nottingham slack gave 72·25 cubic feet of gas, of a calorific value of 145·9 B.Th.U. per cubic foot, while at one-third load it gave 70·85 cubic feet, of 144·5 B.Th.U. The calorific value of the slack was 12,200 B.Th.U. per lb., and the thermal efficiency of the producer was 86·4 per cent. The stand-by losses for fourteen hours out of the twenty-four were, at full load 3 per cent. and at one-third load, 5·7 per cent. of the total fuel consumed. **F. W. Burstall**, in speaking of governing by throttling, said that the troubles found were due to failure in ignition; the only way to properly ignite a weak mixture was by the electric spark, with a variable lead, depending on the mixture. He agreed with Slaby in believing that combustion was complete at the point of maximum temperature, but said that when the charge was extremely weak and the burning slow, there occurred sometimes after-burning, which gave an expansion line just above the adiabatic. According to theory this should give inferior efficiency, because the heat was not added at the maximum temperature, and he had made experiments which bore out this conclusion. **W. Dixon** said there were gas producers with recovery plants in Great Britain of larger size and giving better results than the Mond producer. He criticised the author's figures comparing costs of power on the Mond system and in central electric stations. **D. Clerk** said that the high temperature proper to the production of good gas was antagonistic to the production of ammonia; Mond kept down the temperature by the use of steam in great quantity, and had consequently to make arrangements to recover the heat. He did not consider the producer efficient; the figure of 84·1 per cent. given as the thermal efficiency was misleading, as no account was taken of the heat introduced in the form of steam; allowing for this the efficiency came down to 67 per cent. Further, the quantity of gas generated had not been measured, but only deduced from the weights of carbon in the fuel and that lost in tar and in deposits in the flues. He did not think the efficiency could be over 50 per cent. Referring to Crossley's engine, as the piston was not water-cooled, he thought the makers were right in keeping the compression down to 60 lbs. per square inch. The expansion of the piston was so considerable in large engines that a large clearance had to be left to avoid seizure. **B. Donkin** gave tables showing the results of twelve gas-engine tests with power gas of 150 B.Th.U. per cubic foot, and of six tests of gas engines in America using natural gas, with a calorific value of about 1,000

B.Th.U. per cubic foot. As regards the calorific values of the gases given by the author, he thought the lesser value should be taken, as this was the custom in all countries except France. He compared the thermal efficiency (b.h.p.) of various engines. It varied from about 12 per cent. with steam to about 30 per cent. with oil engines, which were more efficient than gas engines. **W. Robinson** had tested the Mond gas plant and a 500-h.p. Premier engine at Sandiacre, and found a thermal efficiency of over 30 per cent. He noted the remarkable uniformity in the quality of the Mond gas. He was convinced of the accuracy of the author's estimate of the quantity of gas, as calculated from the carbon. The efficiency found at Sandiacre for the Mond producer was 70 per cent. In the Dowson gas producer the composition of the gas was very variable; in a two-days' test, with regular charging and constant steam pressure, it varied between 137 and 170 B.Th.U. per cubic foot. **W. J. Crossley** compared the figures given for his engine and the Premier engine, showing that the friction loss in the latter was 18·78 per cent., while in his it was 9·33 per cent.; he thought that positive scavenging, which accounted for this difference, was too expensive. **E. B. Ellington** criticised the author's comparative figures for the cost per unit in actual and ideal steam stations and in a Mond gas station. He considered that the total cost for fuel with Mond gas would be 0·15d. instead of 0·048d. In the London Hydraulic Power Company's Wapping station, for the whole year the cost per unit of fuel was 0·215d., and of all station charges 0·465d.; the load factor was only 39 per cent. From a comparison of the costs and the thermal efficiencies of steam and gas engines, he concluded that the efficiency of a steam boiler was about the same as that of a gas producer. He thought that the saving in fuel obtained by the Mond gas plant was of little importance for central stations, as the rates and charges on capital cost were far more important factors. **J. H. Hamilton** compared the Premier and Crossley engines, to the advantage of the former; he gave full particulars of the Premier engine, pointing out, among other things, that the compression every back-stroke was so arranged that there was never a pull on the connecting rod, thus avoiding all knocking at the joints. **W. C. Goodchild** gave particulars of the gas plant erected by the Midland Railway Company at Leicester. In the last half-year the fuel consumed was 3·1 lbs. per unit, costing 0·34d.

The Author, in reply, said that the cost of sawdust, shavings, and labour in cleaning and refilling the scrubbers amounted to 4d. a day for a 1,000-h.p. plant running continuously. The time taken to start the Crossley 400-h.p. gas engine from rest and to parallel it with the others was 2½ minutes. The engine had run for 57 days with only two stops required by the electrical plant. The balance-sheets of heat quantities for the Crossley and Premier engines were—

	Crossley.	Premier.
Heat converted into work	27·8	33·65
Heat lost in cooling water	24·2	27·56
Heat lost in exhaust and radiation	48·0	38·79

There was no tar at all deposited from the gas issuing from the Mond producer; a very small quantity appeared in the sulphate of ammonia, and that collected from the washers, towers, and mains was too small to have any value. He gave full details of the trial of the Premier engine at Sandiacre works, mentioned by Rollason. He did not agree with Clerk's criticisms; when the Mond plant worked without sulphate recovery, the fuel for steamraising was less than with the Dowson plant; when worked with sulphate recovery, more steam was needed, but against this should be placed the value of the by-products. His estimate of the quantity of gas produced at Winnington had been borne out by the measurements at Sandiacre; Clerk was therefore in error in estimating the efficiency at 50 per cent. At Oberhausen, gas dynamos were regularly paralleled for polyphase working, and gave no trouble.

Communications.—**J. E. Dowson** criticised the figures given in Donkin's table of tests as being in many cases inaccurate. He gave a table of twenty-six tests on different engines working with his gas plant. In reply to Robinson's statement that the quality of Dowson gas was variable, he said that in a 110-b.h.p. plant, in five hours the maximum variation in the calorific value of the gas was 5 per cent. **G. C. Jones** dealt with the efficiency of the Mond plant in detail, and concluded that it was 70 per cent., instead of 84·1 per cent., as given by the author. **M. Münzel,** of the Gas Motoren Fabrik, Deutz, wrote that it was quite practicable to parallel polyphase machines, if the engine were governed by varying the gas admission, not by missing explosions. Electric ignition must be used. He gave indicator diagrams of a 1,200-b.h.p. Deutz engine using blast furnace gas. **J. D. Roots** suggested a method of compounding gas engines, and illustrated it by diagrams. **R. Threlfall** referred to the curve of h.p. lost in fluid resistance; assuming that the resistance in viscous flow is proportional to the speed, he could account for the quicker increase of resistance shown in the curve only by supposing that the viscosity of the gases increased; this would require their temperature to be raised from 20° to 140° C. in the inspiration. He thought it most important to ensure a thorough mixture of the gases by breaking them up into thin streams, as was done in the Premier engine. **B. H. Thwaite** showed by a diagram the effect on the calorific value of producer-gas, of additions of CO, C_2H_4, CH_4, and H; the effect produced by the latter three is so much greater than that produced by CO, that a producer-gas containing them in any quantity must be very variable in calorific value. Measured by volume the heat value of H is no greater than that of CO, and he considered that the ideal power-gas would contain 30 volumes per cent. of CO and 8 of H. The Author, in reply to the written communications, dealt with the various possible ways of considering the efficiency of a gas producer. G. H. B.

1568. *d'Equevilley Valve.* **E. Legrand.** (Locomotion Automobile, 8. pp. 233–235, April 11, 1901.)—This article describes a form of valve for explosion engines, having the exhaust and the admission valve in one piece of mechanism. The exhaust valve is of the usual cone-seated form, but has a large hollow stem. On the face of the exhaust valve a cone-seating is turned to receive the suction valve, the stem of which passes up inside the exhaust-valve stem. A light spring pressing on a thimble at the top of the suction-valve stem keeps this on its seat after a suction stroke has been completed. The exhaust-valve stem passes through a bored cylindrical guide in the cylinder head, and in it are apertures which are normally opposite to the admission pipe, opening into the cylindrical guide of the valve stem. The explosive mixture is thus able to pass through these apertures, down the exhaust-valve stem, and into the cylinder, when the excess of external pressure causes the suction valve to open. The exhaust valve is controlled by a strong spring and operated by any suitable form of cam action.

C. R. D'E.

AUTOMOBILISM.[1]

1569. *Novel Transmission and Control Gearing.* (Horseless Age, 8. pp. 29–30, April 10, 1901.)—This article describes a new form of gearing for motor vehicles, the distinguishing feature of which lies in the fact that, in the variable speed portion of the mechanism, the power is transmitted partly by belt and partly by chain. In the vehicle illustrated the double cylinder horizontal engine is placed at the front of a rectangular tubular underframe, the crank-shaft being parallel to the length of the frame. A sprocket pinion at the back end of the crank-shaft drives by a single chain two sprocket wheels mounted on two counter-shafts parallel to the engine crank-shaft, and lying in the same horizontal plane. One of the sprocket wheels is fixed to its shaft, while the other, which is attached to an internal toothed drum, runs free. On the shaft having the fixed sprocket is keyed a stepped cone pulley, and on that carrying the loose sprocket is a similar stepped pulley running loose on the shaft. An open belt controlled by a striker transmits part of the engine power from the fixed to the loose pulley ; a part is also transmitted by the chain drive to the loose sprocket wheel. The power is delivered to the shaft carrying the loose sprocket and pulley through the internal toothed drum of the sprocket wheel, and through satellite pinions running on spindles fixed to the loose belt pulley, which engage with the internal toothed drum, and with a spur wheel keyed to the shaft carrying the loose drum and sprocket. The power is thus divided up between the belt and chain in a proportion which depends on the rate of rotation of the satellite pinions relative to the internal toothed drum. The whole power is transmitted through the fixed spur wheel and its shaft, and hence through a bevel gear to the differential cross-shaft, and finally by independent chain drive to the road wheels. The gear as illustrated gives four forward and two reverse speeds. C. R. D'E.

1570. *Dawson Car.* (Automotor Journal, 5. pp. 318–319, April, 1901.)—This article describes the vehicle to which has been fitted the Dawson self-starting and reversible petrol engine described in Abstract No. 1731 (1900). The engine is mounted near the front of the underframe, with its crank-shaft lying across the frame. The power is transmitted through a friction clutch and chain drive to a counter-shaft on which run loose three chain pinions, two of which are on one sleeve, while the other is independent. A claw clutch enables either the independent sprocket or the sprocket sleeve to be driven from the shaft. The independent sprocket pinion and one of the pinions on the sprocket sleeve are geared by chains to sprocket wheels running loose on the sleeve of the differential gear on the live rear axle. The other pinion on the sprocket sleeve drives an independent sprocket wheel mounted free on the differential sleeve. By means of a second claw clutch, controlled by the same lever as controls the clutch on the counter-shaft, either the sprocket-wheel sleeve, or the independent sprocket wheel may be caused to drive the live axle through the differential gear. Four speeds are thus obtained, forward or reverse, according to the rotation of the engine. Ignition in the engine is effected by a special design of rotatory magneto machine driven by a chain and epicyclic gear. The magneto supplies low-tension current to a single induction coil, there being a high-tension switch driven from the armature shaft, by means of which the secondary of the coil is coupled to each sparking plug in rotation. The epicyclic gear enables the angular position of the magneto armature to be varied relatively to the crank-shaft, and so enables the point of firing to be readily adjusted. C. R. D'E.

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[1] Electric Automobiles are described in the section dealing with Electric Traction.

GENERAL ELECTRICAL ENGINEERING.

1571. *Rosenthal Accumulator.* (Elect. Rev. 48. pp. 580–581, April 5, 1901.)—The electrodes of this cell are of the pasted type, but particulars as to the preparation of the active materials are not given. The details of the support are shown in a dimensioned drawing. It consists of a very slight grid having all its surfaces covered by active material. The horizontal bars are of circular section and the vertical bars of diamond section. The specific gravity of the electrolyte falls from about 1·300 to 1·170 during a complete discharge. The feature of the cell is its large output for weight, a 24-lb. cell giving 20 amperes for eight hours down to a potential difference of 1·8 volts, and a total output of 13·1 watt-hours per lb. of complete cell. E. J. W.

1572. *Aron Two-Tariff Meter.* **H. Aron.** (Elektrotechn. Zeitschr. 22. pp. 381–382, May 2, 1901.)—In this instrument there are two counting trains alternately thrown into gear with the arbor of an ordinary meter, the number of revolutions of which is proportional to the number of units passed through the meter. The change-over is effected by means of an independent pendulum clock which is electrically wound and drives two wheels, each revolving once in twenty-four hours. These wheels are capable of moving axially, and are each rigidly connected to a sleeve having a circumferential groove, in which one arm of a lever engages, the other arm of which acts on one arm of a three-armed lever, the third arm of this lever being connected by a link to an oscillating frame carrying three gear-wheels, and effecting the actual change-over. The axial motion of the wheels above mentioned is obtained by providing the end of each corresponding sleeve with a **V**-shaped notch, adapted to engage with a tooth on a sleeve having an indicator arm adjustable round a dial divided into 24, springs forcing the wheels and sleeves against the corresponding teeth. By this means, when a notch reaches a tooth, the wheel and sleeve move axially and reverse the oscillating frame through the levers above mentioned. C. K. F.

1573. *Energy Meters.* **P. Janet.** (Soc. Int. Élect., Bull. 1. pp. 64–111, Feb., 1901.)—The author divides the various systems of meters into three classes : (1) Motor Meters, (2) Oscillating Meters, (3) Meters with Intermittent Integration.

In the first class are : (1) *Meters of the Thomson type. Thomson meter* for continuous currents. Improvements introduced into the latest model of this meter are: the brushes are movable about their axis of inertia, so as to be insensible to vibrations, and are made stirrup-shaped so as to ensure contact at two points on each brush ; the brushes and lower pivot can be examined without opening the case, which is hermetically sealed. Tests on a 10-ampere meter show a consumption of 2·77 watts on 100 volts, and 3·35 watts on 110 volts; the starting watts are 0·7 per cent. of the maximum. In the alternate-current meter, Frager has introduced a correction for the lag in the shunt circuit by producing an equal lag in the series circuit; this is accomplished by placing in the main coils a winding short-circuited on itself. The effect of this is to reduce the error, when indicating on low power-factors, to about half its value; on a power-factor of 0·27, the error was 4 per cent.

Lux meter by the Luxsche Industrie Werke. This differs from the Thomson meter only in the form of the armature, which consists of three flat coils with axes at 120°; for the same torque this form is lighter than the ordinary form in the ratio 1 : 1·7. *Vulcain meter* [Abstract No. 1419 (1899)]. Tests of a 10-ampere meter showed a consumption of 2·01 watts at 100 volts, and 2·43 watts at 110 volts; starting watts 0·4 per cent. of maximum. *Schuckert meter.* This differs from the Thomson only in having the position of the compound winding adjustable, for the purpose of regulating the friction compensation. The continuous-current meter for 150 amperes shows a consumption of 6 watts on 220 volts; the alternate-current 10-ampere meter, 4 watts on 110 volts; starting watts 0·8 per cent. of maximum watts. On power-factors of 0·5 and 0·07 the errors are, respectively, 4 per cent. and 17 per cent. *Perdrisat meter* by the Société Perdrisat, Blanc & Cie. This meter contains iron in the armature; it is very simple and light, the 50-ampere size weighing only 6 kilos. *Peloux meter* [Abstract No. 1420 (1899)].

(2) *Rotary field meters.* The author describes in detail the principles on which this type of meter is based. The following are described: *Blathy meter. Hummel meter.* In this a lag of exactly 90° is produced in the pressure circuit by shunting the coil with a non-inductive resistance, and joining in series with these two coils an inductive resistance. *Helios meter. Raab meter,* by the Elektrizitäts-Aktiengesellschaft vormals Schuckert. In this the main, shunt, and damping fields all act on the same disc. A phase-lag of 90° is produced in the shunt circuit by winding two coils in parallel on two electromagnets; one produces the main field, not quite 90° out of phase, the other, wound in opposition, is in series with a non-inductive resistance, and gives a weak field with small lag; the two fields can be adjusted to give a resultant with a lag of exactly 90°. The 10-ampere meter takes 2·5 watts on 115 volts; with a power-factor of 0·4, the error is only 3 per cent. *Hartmann and Braun's meter* [Abstract No. 724 (1900)]. *Batault meter,* by the Société Genevoise. In this the shunt electromagnet has a double core, with winding on one leg only, and a short-circuited winding embracing both legs; by adjusting the resistance of the latter, the phase-lag is brought to exactly 90°.

(3) *Three-phase motor meters.* In a three-phase star circuit there are three expressions for the power, applicable in the case of unequally charged lines—

$$W = e_1 i_2 - e_2 i_1, \qquad 2W = i_1(e_3 - e_2) + e_1(i_2 - i_3),$$

and—

$$3W = (i_1 - i_3)(e_3 - e_2) + (i_2 - i_3)(e_1 - e_3),$$

where, if V_1, V_2, V_3 be the potentials of the star ends, i_1, i_2, i_3 are the currents in the corresponding lines, and e_1, e_2, e_3 are equal, respectively, to $V_2 - V_3$, $V_3 - V_1$, $V_1 - V_2$. Each expression gives rise to a method of combining a field in phase with the current with one in quadrature with the pressure on each of two discs mounted on one axis. In the case of three-phase currents it is more easy than with alternating currents to produce a field in quadrature with the tension, as it can be done by producing a lag of less than 90° by a simple inductive coil. In the case of the first expression three methods have been patented respectively by Hummel, Siemens and Halske [Abstract No. 1764 1899)], and Schuckert. The first consists in producing a field lagging 30° behind e_3 to represent e_1 in the term $e_1 i_2$, and similarly for the other term $e_2 i_1$; the second is to produce a field in phase with $V_1 - V_0$, which lags 90° behind $-e_1$, V_0 being the potential of the neutral point, which may be produced artificially in the meter by three similar coils; the third is to produce a field lagging 60° behind $V_0 - V_2$, which then lags 90° behind e_1. The second expression for power has been applied to a meter by Möllinger [Abstract No. 2312 (1900)], by creating a dissymmetric neutral point, so that $V_0 - V_3$ is 15° in advance of e_1, and $V_0 - V_1$ is 75° behind; coils producing lags of 75° behind these tensions then give fields in quadrature with $e_3 - e_2$ and e_1. The third expression is applied by producing fields lagging 60° behind e_2 and e_3 respectively. To produce the same torque the three systems absorb power in the respective ratios of 1 : 0·557 : 0·667.

Under the second head of Oscillating Meters, the author describes the *Aron meters*, applicable to continuous or alternating currents, also with double tariff (see preceding Abstract), to the charge and discharge of accumulators, to three-phase current, also with transformer, and to three-phase current with four wires [Abstract No. 1119 (1901)], and the *Allgemeine Elektrizitäts-Gesellschaft meters* [Abstract No. 1892 (1901)].

In the third class of Intermittent Integrating Meters are described *Brillié's meter, Brown and Routin's meter, Siemens' meter*, and *Holden's meter* [Abstract No. 2311 (1900)].

The Vulcain prepayment meter is described [Abstract No. 579 (1900)], and Brown and Routin's sliding scale meter [Abstract No. 1765 (1899)]. G. H. B.

1574. *Insulation on Cables.* **M. O'Gorman.** (Inst. Elect. Engin., Journ. 30. pp. 608–683; Discussion, pp. 684–700, May, 1901.)—A high insulation resistance is useful in feeders, chiefly to facilitate fault-finding; in distributors, where exposed terminals are frequent, it is of less importance. High insulation does not necessarily go together with high disruptive strength, and undue insistence on this quality precludes the use of many low-priced dielectrics which in other respects are suitable. In determining the thickness of dielectric required for a given disruptive strength, a factor of safety as high as 20 is sometimes used. A high factor is employed on account of the possibility of dirt, moisture, or bubbles finding their way into the dielectric; and, further, some dielectrics become polymerised, or give off gas, when subjected to an alternating e.m.f.

The author gives curves showing how rapidly the thickness of insulation must increase with increase of pressure, for a given maximum stress in the dielectric; the rate of fall of potential in the dielectric diminishes from the conductor outwards, and consequently the depth and cost of insulation increases far more rapidly than the voltage. For instance, allowing 20,000 volts per centimetre, a 37/14 cable would require 0·5 inch of insulation for 10,000 volts, and 1·89 inches for 20,000 volts.

The author proposes three methods for diminishing the thickness of insulation required, by utilising to the full its dielectric strength throughout its thickness. The first method is to make the dielectric strength of each layer of insulation proportional to the voltage gradient in that layer, by using materials of varying dielectric strength. Not much improvement can be looked for in this direction, as the strongest materials are commonly used throughout the insulation. The second method is to vary the specific conductivity of the different layers so as to produce a uniform rate of fall of potential. If this were done, the thickness of dielectric required for the 37/14 cable mentioned, at 20,000 volts, would be only 0·55 inch instead of 1·89 inches. When the insulation consists of paper impregnated with rosin oil, the conductivity of the inner layers can easily be increased by adding a very small percentage of linseed oil. The large effect of small impurities, however, and the temperature coefficient of the oils, destroy to some extent the value of this method, which, besides, is only useful for continuous currents. The third method is to vary the specific capacity of the different layers, so that, considering the dielectric to be made up of a number of cylindrical condensers, the capacity of each is the same, in spite of the difference in their size. The author calls this "grading the capacity," and suggests various ways in which this varying specific capacity could be secured; for example, by the use of castor oil to increase the capacity of rosin oil. Formulæ are given for the calculation of the capacity of two-wire, three-wire, and other cables. He notes that many substances, notably oiled paper, empire cloth, and mica, have apparently a higher disruptive strength in small thicknesses than in large, and quotes Perry as explaining this by skin resistance.

The author then proceeds to deal with the cost of cables, which he works out as curves for several examples of transmission, on different systems and at different voltages, incidentally showing a 30 per cent. economy by grading, and showing when two single cables are cheaper than concentrics. The Board of Trade rule requiring 1/20 inch of insulation per 1,000 volts, weighs heavily on large cables, which are shown by curves to require less thickness of dielectric for a given voltage than small ones.

In appendices are given: (1) A table of the price, dielectric strength, specific capacity, and insulation resistance of a large number of dielectrics; (2) A table of Gray's results on the dielectric strength of various oils in layers of different thicknesses; (3) A table of current densities and losses in wires of different sizes at different frequencies; (4) A table giving capacity measurements of the three members of a three-wire cable before and after being laid up together; (5) Tables comparing the cost of cables on direct and one-, two-, and three-phase transmission, for delivering a given amount of power, on the basis of the same maximum voltage between any two conductors; (6) Two appendices on the capacity of cables; (7) A table of sizes and prices of three-phase, lead-covered, armoured cables, for different voltages.

G. H. B.

1575. *Granite as an Insulator.* (Frank. Inst., Journ. 151. pp. 309–312, April, 1901. Report of a Committee.)—Granite chips are calcined, and powdered felspar and kaolin added with water to make a plastic mixture, and the moulded objects heated to 3,000° F. and glazed. The product absorbed 0·76 per cent. of water in a year. It crushed at 7,000 lbs. per square inch; showed a tensile strength 900 lbs. per square inch; and a sample of a size not stated had an insulation resistance of 8 megohms.

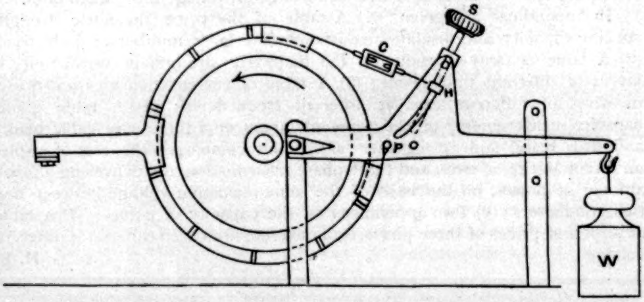
M. O'G.

1576. *Electric Cranes.* (Zeitschr. Vereines Deutsch. Ing. 45. pp. 433–437, March 30, 1901.)—An account is given of a crane mounted on a truck travelling on rails of 1·92-metre gauge. The lifting rope, after passing over the pulley at the outer end of the jib, is guided down the centre of the hollow pillar on the top of which the jib is mounted. The jib is free to rotate. Current is taken from three overhead wires fed with three-phase currents. These wires rest freely at intervals on supports, from which they are lifted by the sliding contact-makers fixed on the crane. In order to carry the current down to the motors there are slip-rings and brushes above and also below the rotating part of the crane. Worm gearing is used to drive the rotating part; and, with the object of preventing damage to this non-reversible gearing by the momentum of the moving jib when the current is switched off, the jib is not driven rigidly, but by friction. The truck is moved through worm and chain gearing.

A short description is also given of a three-phase crane for harbour use. The winding-drum is driven by a claw-coupling, which can be disconnected when lowering.

A number of drawings are included. W. H. E.

1577. *Adjustable Prony Brake.* **F. Hubert.** (Elektrotechn. Zeitschr. 22. pp. 339–341, April 18, 1901.)—The construction of the brake will be understood from the accompanying sketch. The brake pulley is provided with inwardly projecting flanges which provide a water-cooling arrangement. The brake band is fitted with the usual wooden blocks. One end of the band is attached to the point P of the brake lever, while the other end is connected to the coupling C, by means of which the brake band may be tightened. The other end of the coupling is attached to a cross-head H, which is capable of sliding along a curved slot, the adjustment being obtained by means of a screw S. There are thus two ways of tightening the brake strap—one by means of C, the other by means of S. An upper and a lower stop limit the play of the lever during the time that the adjustment is being made. The end of the lever away from the weight W is slotted, and between the two prongs of the fork is a pin which is fixed to the frame of the machine. If the friction is too small, the upper prong bears against the pin. Should, on the other hand, the friction become too great, the lower prong is driven up against the pin, which now becomes the fulcrum of the lever, and any further tendency to carry round the brake is automatically checked, since it results in a slackening of the brake band.



A. H.

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1578. *Characteristic of the Lead Accumulator and its Dependence on Electrode Construction.* **H. Wehrlin.** (Centralblatt Accumulatoren, 2. pp. 33–34, Feb. 1; and 49–53, Feb. 15, 1901.)—A paper on the same lines as that noticed in Abstract No. 218 (1901). The relation between e.m.f., capacity, and time of discharge is discussed and characteristic curves are given for different types of accumulators. N. L.

1579. *Torpedoes Steered by Wireless Telegraphy.* (Scientific American, 84. pp. 101–102, Feb. 16, 1901.)—Description of some very successful experiments carried out in the English Channel with the torpedo invented by C. Varicas. J. E.-M.

GENERATORS, MOTORS, AND TRANSFORMERS.

1580. *Direct-Current Generators.* **S. H. Short.** (Electrician, 46. p. 905, April 5, 1901. Abstract of a paper read before the Manchester Section of the I.E.E., March 26, 1901.)—Starting from the consideration that in the design of direct-current generators the tendency is towards an increase in the number of poles, and that there is, generally speaking, an approximation towards the modern type of alternator, the author proposes on these lines a method of standardising direct-driven dynamos. A "unit machine" is taken (bipolar) of which the electrical and magnetic data are calculated so as to give the best possible results. For a machine of double this output the author doubles the number of poles and the diameters of armature and commutator, and halves the speed, thus keeping all the other values—magnetic flux, current density, surface speed, &c.—the same as in the two-pole machine; for a machine of four times the output of the unit dynamo, the number of poles, the armature and commutator dimensions are again doubled and the speed again halved; and so on. In this way the same field and armature coils, brushes, holders, commutator bars, &c., can be used for any size of machine (working at the same voltage), thus diminishing the cost of manufacture. A table is given showing the different values of speed, output, armature and commutator diameters, and output per 100 revs. for different numbers of poles up to 30.

For the larger sizes of machine, the surface density of the current in the armature may be increased from 500 to 600 or 700 amperes per inch of width, thus lowering the number of poles, decreasing the diameter of the armature and increasing the speed. B. P. S.

1581. *Saturation of Armature Teeth.* **J. Fischer-Hinnen.** (Écl. Électr. 27. pp. 146–147, April 27, 1901.)—The author disagrees with Rothert [Abstract No. 1410 (1901)], who says that the saturation of the teeth should be as high as possible. He gives particulars of a number of machines which work with fixed brushes without sparking, with 7,300 to 15,000 lines per sq. cm. in the teeth, while Rothert suggests 23,000 to 25,000. He also says that the practice of winding several sections in one slot is well known, but seldom used because it causes sparking. R. B. R.

1582. *Weights of Generators, Motors, and Transformers.* **E. E. Seefehlner.** (Zeitschr. Elektrotechn., Wien, 19. pp. 233–236, May 12, and 245–247, May 19, 1901. Paper read before the Elektrotechnische Verein, April 10, 1901.)—Sets of curves are given to show the relation between weight and output, the data having been obtained from fifteen of the largest works of different countries. The average results, expressed as kg. per kw., are condensed in the annexed table :—

	Full load output in kilowatts.			
	10	50	100	200
Generators	73	42	42	45
Direct-current motors	56	45	39	—
Induction motors	37	31	31	—
Transformers	36	26	24	22

W. H. E.

1583. *Predetermination of Drop in Alternators.* **G. Giles.** (Ecl. Électr. 27. pp. 90–102, April 20, and 137–146, April 27, 1901.)—The author develops a method of calculating the drop of p.d. in alternators which is based mainly on the consideration of the reluctances of the air-gap and the leakage paths. Let the open-circuit characteristic of the alternator be given. If $R_1 =$ reluctance of air-gap (corresponding to useful flux), $R_2 =$ reluctance of leakage paths, $Si =$ demagnetising ampere-turns due to armature when the power-factor is zero, and if we suppose that the total magnetic flux through the field core is the same as it was on open circuit; then in order to pass from any point on the open-circuit characteristic[1] to a corresponding point on the internal characteristic, we have to reduce the volts by an amount corresponding to the flux $\frac{4\pi}{10} \cdot \frac{Si}{R_1 + R_2}$, and to increase the ampere-turns by an amount, $Si \frac{R_2}{R_1 + R_2}$. In order to find the external characteristic, we have further to subtract from the ordinate of the internal one an amount corresponding to the impedance drop in the armature. In order to obtain this latter correctly, the author uses an experimental armature coil of very fine wire superposed on the main coil and connected to a voltmeter. If the alternator is run on short-circuit with a current corresponding to the load current, the true impedance drop is easily found from the voltmeter reading and the number of turns in the exploring and main armature coils. The author next investigates the effect of damping-coils, and shows that if damping is perfect, then the armature back-turns are (power-factor $= 0$) given by $\frac{1}{2} SI_0$, where I_0 is the *maximum* value of the armature current (sine function assumed). If there are no damping-coils, then the e.m.f. of the alternator when loaded contains a third harmonic *even if the open-circuit e.m.f. is a pure sine wave.* The results are applicable to two- and three-phase machines, the back-armature turns of which are (power-factor $= 0$) given by SI_0 and $\frac{3}{2} SI_0$ respectively. Experimental results are given in support of the theory developed. A. H.

1584. *Testing Three-Phase Generators.* **M. Breslauer.** (Zeitschr. Elektrotechn., Wien, 19. pp. 185–187; Discussion, p. 187, April 14, 1901.)—A complete test of a large three-phase generator is frequently attended with difficulties, on account of having to provide the necessary large amount of power, and the three equal non-inductive load resistances. On a non-inductive load, which is the load generally employed in carrying out such a test, the drop from no load to full load should not exceed 3 per cent. in good machines of moderate output, and should not in any case be greater than 6 per cent. A very good estimate of the qualities of a machine may, however, be arrived at without actually running the machine at full load, by making use of the open-circuit (exciting current and voltage) and short-circuit (exciting current and armature current on short-circuit) characteristics. In order to find the load characteristic of the machine under constant excitation (the load being non-inductive), a right-angled triangle is constructed whose hypotenuse is equal to the constant exciting current, and one of whose sides is equal to the exciting current required to produce the given load current on short-circuit. The point on the open-circuit characteristic corresponding to an exciting current equal to the remaining side of the right-angled triangle then gives the terminal p.d. at that load. The author tested this theoretical method on a machine giving very bad regulation (and therefore very suitable for the purpose), and found practically perfect agreement between theory and experiment. A. H.

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[1] The *open-circuit* characteristic connects field-ampere-turns with open-circuit e.m.f., the *internal characteristic* connects them with e.m.f. corresponding to a given armature current and power-factor, and the *external* characteristic with p.d.

1585. *Design of Rotary Converters.* **H. S. Meyer.** (Elektrotechn. Zeitschr. 22. pp. 295–299, April 4, 1901.)—The author first deals with armature reaction and heating. Formulæ are given for the armature reaction corresponding to a power-factor of unity. Assuming a sine wave of current and a power-factor of unity, the output of a given machine when used as a three-phase converter is 1·84 times its output as a continuous-current generator. The various steps in working out a design are next dealt with in the following order: (*a*) The output, frequency, and voltage are given; the author states that the most favourable frequencies, from the designer's point of view, are from 25 to 30, that 30 to 40 are still admissible values (and in the case of small machines up to 50), but that with higher frequencies troubles are experienced on account of sparking. (*b*) The number of poles, and with it the revs. per min., are found by allowing a current not exceeding 300 amperes per brush bar. (*c*) The diameter is determined by allowing a peripheral velocity of not less than 28 metres per sec. (to secure good ventilation), and not more than 38 metres per sec.; further, the quotient of the diameter by the number of poles should not be less than 10 cm. (*d*) As regards armature reaction, since this is less in converters than in continuous-current machines, the full-load armature ampere-turns per pole may in general be assumed equal to, or greater than, the field-ampere-turns per pole at no load. (*e*) The voltage per commutator segment should lie between 10 and 16 volts. On the assumption of two commutator segments per slot, this immediately gives the number of slots in the armature core. This number should be so chosen as to make it divisible by the product of the number of poles into the number of phases. (*f*) On account of the smaller heating as compared with continuous-current machines, a current-density (taking the full-load continuous current) of from 450 to 600 amperes per sq. cm. may be allowed in the armature conductors. (*g*) The slots should be shallow and preferably open, or only partially closed. The armature winding is always a parallel winding. (*h*) The length of the polar arc should be from 70 to 80 per cent. of the polar pitch. The leakage coefficient would be about 1·2. (*i*) The induction may range from 6,000 to 9,000 in the armature core, from 16,000 to 20,000 in the teeth, from 7,000 to 9,000 in the air-gap, from 12,000 to 14,000 in the pole-piece, and in the yoke it may be 5,000 for cast-iron and 9,000 for wrought-iron. (*k*) The length of the armature core is easily found from the length of the pole-arc, the permissible induction and the total magnetic flux per pole; ventilating apertures should be provided in the armature core about every 12 cm. (*l*) The pole-shoes should be shaped so that the air-gap increases in length close to the edge of the pole-piece, in order to widen the zone of sparkless commutation. (*m*) The peripheral velocity of the commutator should be high, up to 25 metres per sec. The thickness of the *micanite* insulation between segments should be from 1 to 1·25 mm. The brush thickness varies from 2½ to 3½ commutator segments, and the total length of commutator is obtained by assuming a current-density of 4·5 to 6·5 amperes per sq. cm. of contact area (carbon brushes). Two devices are described for securing even wear of the commutator by giving the armature an axial oscillation. In one of these, an annular electromagnet whose circuit is periodically closed is attached to the end of the bearing, and pulls the armature shaft in an axial direction, while in the other an inclined end-plate is employed, the end-plate and shaft being provided with a circular groove in which runs a ball. The author finally considers the efficiency and hunting of rotary converters. A. H.

1586. *Haselwander's Single-phase Induction Motor.* **H. Michel.** (Zeitschr. Elektrotechn., Wien, 19. pp. 169–171, April 7, 1901.)—The construction of this motor will be understood by reference to the accompanying sketches. Fig. 1 is a diagram of the ordinary form of single-phase motor, EE denoting the two stator coils, which produce a field indicated by the dotted straight lines; i_1, i_2, m_1 and m_2 are the rotor coils, which are connected to two short-circuiting rings (dotted circles), s_1 and s_2. In the position of the rotor shown in the figure, i_1 and i_2 act as sources of secondary e.m.f., but the motor coils m_1 and m_2 receive no appreciable current, since practically the whole of the current flows round the copper rings. If, however, the arrangement devised by Haselwander, and illustrated in Fig. 2, be adopted, the motor becomes capable of exerting a torque when at rest. One end of each coil is connected to a copper ring. The other ends of the coils are connected with the interposition of choking coils *w*. The impedance of each choking coil is, for a certain position of the coil, greatly increased by a fixed inductor TT. The result is that the coil *m* will, in the position shown, receive current from *i'*, and the coil *m'* current from *i*, the coils w_1 and w_3 exerting a powerful throttling action. Various modifications of this principle are illustrated. A. H.

FIG. 1.

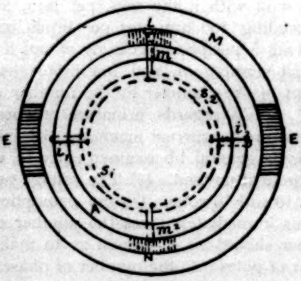
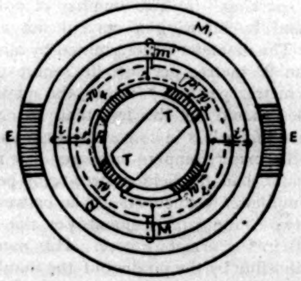


FIG. 2.



1587. *Effect of Irregularities in the Field of an Induction Motor.* **R. Goldschmidt.** (Elektrotechn. Zeitschr. 22. pp. 335–339, April 18, 1901.)—It has been customary, in dealing with induction motors, to assume that the space-distribution of the magnetic flux in such motors follows the simple sine law. Certain facts, however, such as the dependence of the starting torque and short-circuit current on the position of the rotor relatively to the stator, can only be accounted for by irregularities in the distribution of the magnetic flux. The author makes a detailed study of these irregularities, and supposes that the actual motor is replaced by a number of ideal motors whose stator windings are coupled in series, and are so arranged that the consecutive stator windings produce fields whose polarity corresponds to the various simple harmonic components of the actually existing field. The rotor windings are also coupled in series with each other, and all the rotors are supposed to be mounted on the same shaft. The author comes to the conclusion that a rotor whose power-factor is very high will not start even when unloaded, and will show dead points; and that in all calculations based on the assumption of sine waves of p.d. and current, and having reference to a speed not far removed from that of synchronism, the assumption of a single simple sine field (in space) furnishes sufficiently accurate results. A. H.

1588. *Starting Device for Single-phase Induction Motor.* **M. Osnos.** (Zeitschr. Elektrotechn., Wien, 19. pp. 196–199, April 21, 1901.)—The author suggests a starting device which consists essentially of an arrangement for disconnecting a portion of the ordinary stator winding of the motor and closing it through an external non-inductive resistance. The portion of the winding so disconnected acts like the secondary of a transformer, the result being the production of an auxiliary field which differs in direction and phase from the main field. When the motor has run up to speed, the short-circuited portion of the winding is reintroduced into the circuit of the main winding, and the motor goes on running as a simple single-phase motor. The author points out that such an arrangement involves no additional special winding, but only a suitably designed starting switch and non-inductive resistance. The method has not, however, been tested practically. A. H.

1589. *Diagrams for Special Cases of General Transformer.* **K. Kuhlmann.** (Elektrotechn. Zeitschr. 22. pp. 341–344, April 18, 1901.)—The author deals graphically with the following problems: (1) That of the general transformer without any inductive resistances in the secondary circuit (induction motor), the primary p.d. being supposed constant. He shows that the locus of the extremity of the primary current vector is a circle, and gives an account of experiments carried out with an induction motor, which show remarkably close agreement with the theoretical values deduced from the diagram corresponding to this motor. (2) That of the general transformer, the secondary power-factor being constant. In this case also the extremity of the primary current-vector traces out a circle. The same result is next shown to hold for the most general case, the secondary inductance being assumed constant, and the power-factor variable. A. H.

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1590. *Starting Resistances for Induction Motors.* **O. Bergmann.** (Zeitschr. Elektrotechn., Wien, 19. pp. 137–138, March 24, 1901.)—A brief contribution dealing with the problem of designing a starting resistance for a three-phase induction motor in such a manner as to enable the torque of the motor to be kept approximately constant. A. H.

1591. *Tramway Motors.* **S. H. Short.** (Elect. Rev. 48. pp. 545–547, March 29, and 589–593, April 5, 1901.)—Two articles, illustrated by several process blocks, describing generally the construction of tramway motors.

1592. *Induction Motor Diagram.* **J. K. Sumec.** (Zeitschr. Elektrotechn., Wien, 19. pp. 177–180, April 14; and 193–196, April 21, 1901.)—This is a very thorough treatment of the induction motor problem, the resistance-drop in the stator windings being taken into account. The locus of the primary-current vector is shown to be a circle, while the heat losses, the output, torque, slip and efficiency are all capable of being represented in the diagram by means of straight lines. A. H.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

1593. *Efficiencies of Small Lighting Plants.* **A. W. Richter** and **B. V. Swenson.** (West. Soc. Engin., Journ. 5. pp. 471–481; Discussion, pp. 484–487, 1900.)—This paper embodies the results of detailed tests made upon four small electric lighting plants, of powers ranging from 50 to 700 i.h.p. Three of these use belt-driving, and several of them supply power for pumping or traction in addition to the lighting load. The coal used per i.h.p.-hour varied from 2·58 to 9·1 lbs.; the average efficiency (e.h.p. : i.h.p.) was from 53·2 to 74·6 per cent., and the thermal efficiency of the engines was 6·15 to 11·20 per cent. Full details of the results are given, with diagrams showing the distribution of the losses through the plant. The proportion of the whole energy of the coal which was delivered at the switchboard ranged from 1·87 to 5·69 per cent.

The discussion turned upon details of the tests. A. H. A.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

1594. *Manchester Electricity Works.* (Electrician, 46. pp. 926–932, April 12, 1901.)—This article gives an account of the changes which are in progress at Manchester. A large power station is being erected at Bloom Street, which is to have a capacity of 14,000 i.h.p. This is close to the Dickinson Street station, which has a capacity of 12,000 i.h.p. A third generating station is to be erected at Stuart Street, having eventually 50,000 i.h.p. installed. Continuous current is to be supplied to the consumer throughout; in the central area there will be a five-wire system, and in the outer area a three-wire system; in both cases the pressure between the outers will be 400 volts. At Stuart Street three-phase current will be generated at 6,500 volts, and be transmitted to a large number of substations, about a mile apart, where, by means of static transformers and rotary converters, it will be distributed as continuous current. A heavy demand is anticipated from the tramways, and as the result of spacing the substations at short intervals it is hoped that the maximum drop in the rails will be kept below 1¼ volts. At Bloom Street the engine-room will contain four steam dynamos, running at 75 r.p.m., and giving about 1,900 kw., either at 440 volts as shunt machines, or at 500 volts as compound-wound machines, the higher voltage being intended for the trams. The boiler-house will contain eleven Babcock boilers, each fitted with a superheater, and having a heating surface of 5,140 square feet. The economisers are to be fitted above the boilers, each boiler having its own economiser. The main flues will therefore discharge into the chimney at a level of 80 feet above the ground. The chimney is octagonal, 230 feet high and 12 feet across the octagon inside. This station is not yet complete, though it had been expected that it would have been in working order before last winter. No work appears as yet to have been done on the Stuart Street station, but mains have already been laid throughout the district. There will be 30 cables leaving this station, owing to the requirements of the Board of Trade that no cable shall carry more than 1,000 kw. All three-phase feeders are of the same size, and are made up of three conductors, each 0·15 square inch in sectional area; they are lead-covered and armoured, and are laid in cast-iron troughing on the solid system. The troughs are 9 feet in length, and contain either two or three cables. One of the bridges in every length of troughing is of malleable iron, and is secured by set screws to the troughing; an iron clamp is then placed over the cable, and connected to the bridge so as to secure contact between the armouring and the length of troughing. In this way the troughing is made electrically continuous. The joint boxes are of special design, of which drawings are given. The mains were tested with a pressure of 18,000 volts between each conductor and earth, the other conductors and the armouring being connected to earth during the test.

A certain number of 100-kw. rotary converters have already been installed and put to work, though the method of working is intended as a purely temporary expedient. The system adopted is, however, interesting, as also is the method of testing. Continuous current at 440 volts is supplied to the rotaries, and by them converted to three-phase current at about 260 volts. This pressure is raised by static transformers to 5,000 volts, and the power is then transmitted to a distant substation, where, by an inversion of the preceding process, it is reconverted to continuous current. At the substations the step-down static transformers have connections made to ten different points on the low-pressure winding, and these connections are brought out to terminals. By this means the regulation of the three-wire network is done without the aid of any balancers, the static transformers having their windings connected in a star, the common junction being connected to the middle wire of the distributing system. The rotary therefore supplies current direct across the outers. The testing was carried out as follows. Continuous current was supplied to a rotary converter, and by it converted to three-phase current; this was stepped up by one transformer and down by another, and then passed through a second rotary, the continuous current given out being absorbed by a resistance. Under these conditions the efficiency was determined by comparing the inputs and outputs on the continuous-current sides, and in some cases this efficiency turned out as high as 81 per cent. at full load. Very similar results were given by a modification of the Hopkinson test, the continuous current from the second rotary being returned to the first. Figures are given showing the efficiency of the combinations at various loads.

The article contains drawings showing the connections on the switchboard for the three-phase transforming plant, the design of a disconnecting box for three-phase cables, the arrangements in the boiler-house to allow for expansion in the steam-pipes, and also a plan of the district to be dealt with by the various substations. W. H. S.

1595. *Power Station of the Union Traction Company, Indiana.* (Street Rly. Rev. 11. pp. 203–212, April, 1901.)—System: Power generated by three-phase alternators, transformed up to high-pressure, and transmitted to substations equipped with step-down transformers and rotary converters. The boiler-room contains six Babcock boilers, each having a heating surface of 4,000 square feet, and working at a pressure of 155 lbs. per square inch. Each boiler is fitted with a firebrick arch 3 feet deep at the front end, forming a combustion chamber.

The feed water is heated by a Stillwell-Bierce exhaust steam heater, receiving the exhaust from the auxiliary engines, and capable of heating 120,000 lbs. of water per hour from 60° F. to 212° F.

Coal is stored in elevated bunkers, from which it is fed by spouts to the boilers, and is fired by Babcock chain grate mechanical stokers. A complete coal and ash conveying equipment is provided.

The engine-room contains three cross-compound Corliss automatic cut-off condensing engines, each having cylinders 26 and 50 inches diameter, stroke 48 inches, and capable of giving a maximum of 2,000 i.h.p. at a speed of 100 r.p.m. There is a separate jet condenser to each set.

Each engine drives directly a three-phase Westinghouse alternator, giving 1,600 amperes in each phase at a pressure of 400 volts, with a power-factor of 90 per cent., at a frequency of 3,200 cycles per minute. The alternators can be excited by a motor-dynamo, a steam-driven dynamo, or a storage battery.

The current is transformed up to 15,500 volts by means of fifteen 250-kw. transformers, and is transmitted by four overhead feeder lines to eight substations, equipped with step-down transformers and rotary converters. There are also three converters in the main station.

There is a storage battery of 264 Chloride cells in the main station, rated at 211 kw. for one hour, and each of the substations is equipped with a similar battery of either 168 kw. or 84 kw. The operation of these batteries has proved highly successful and economical.

A portable substation, consisting of a rotary converter, transformers, &c., mounted on a car, is kept in readiness for hauling to any of the substations in case of emergency.

The track is equipped on the direct-current overhead trolley system, and is in all 163 miles in length, including long stretches between several large towns. For the interurban service 25 new cars have recently been provided, each seating 52 passengers and having a baggage compartment. Each car is mounted on a Baldwin motor truck, equipped with two 150-h.p. Westinghouse motors, and a trailer truck, and is intended to run at a speed of 42 miles per hour under favourable conditions.

The description of the power station and of the substations is fully illustrated. A. H. A.

1596. *Electrical Plant in an Engineering Shop.* **W. Philippi.** (Elektrotechn. Zeitschr. 22. pp. 2-9, Jan. 3, 1901.)—A description of the power and lighting installation at the Sächsische Maschinen-Fabrik of Chemnitz. Three-phase current at 120 volts was chosen for the lighting network, partly because 3 arcs could then run in series and partly to have the advantage of the town supply as a reserve. For power purpose 500 volts direct current was installed.

The boiler-house is built for 4, and contains 2 water-tube boilers, Gehre system, concerning which the chief data are as follows: Heating surface 200 sq. m.; pressure, 12 atmospheres; 108 water tubes, outside diameter, 108 mm.; 12 superheating tubes (to ensure dry steam), 95 mm. outside diameter: width of drum, 1,500 mm.; length of drum, 6,850 mm. A specially shaped fire-bridge, together with a "Leach" mechanical stoking apparatus, secures smokelessness, with a saving of 10 per cent. in coal and an increase of 25 per cent. in duty, as compared with hand firing. Coal-handling plant is provided.

The steam plant comprises two 500-h.p. sets with room for a third. The engines are triple condensing, rated at 575 i.h.p. or 500 b.h.p., and a maximum of 650 b.h.p. at 150 r.p.m., with steam at 11 atmospheres; cut-off in the h.p. cylinder at normal load is at 0·3 of stroke; steam consumption at normal load, 5·8 kg. per i.h.p. per hour; cylinder diameters, 425 mm., 665 mm., and 1,060 mm., by 600 mm. stroke.

The three-phase generators are rated at 725 amperes at 500 volts on non-inductive load, and carry their own direct-connected exciters. There are at present some 60 motors, aggregating 1,700 h.p., the largest being 105 h.p.

Allowing 5 per cent. for interest on the whole installation, 5 per cent. depreciation on plant inside the generating house and 3·5 per cent. on outside plant, &c., the costs per h.p.-hour are 4 pfennig measured at the generators, or about 5·5 pfennig, measured at the motors. E. H. C.-H.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

1597. *Lorain Steel Company's (Brown's) Surface Contact System.* (Tram. Rly. World, 10. pp. 141–145, March, 1901.)—Contact boxes are spaced 8 to 16 feet apart and are connected on to the feeder conduits by a Y-casting, the maximum depth required being 15 inches. The base of the contact box is preferably made of "reconstructed granite," a material as durable as granite and as good an insulator as the best porcelain. In a recess in this base is an hermetically sealed vulcasbeston cup containing the circuit closer. At the top of the cup is a carbon contact connected to the surface knob. The corresponding contact is carried on a soft-iron plate, 4¾ × 2 × 1/16 inches, which is normally resting on a ledge at the bottom of the cup and is connected to the feeder through a thin, hard-rolled copper strip folded on itself. The top of the box consists of hard non-magnetic manganese steel in the centre where the contact-shoe rubs, and iron on either side. The car carries a shoe flanked by magnets whose magnetic circuit is closed through the soft-iron plate carrying the carbon contact, which is thus connected to the surface knob. The poles of the magnets on the car are composed of a number of separate plates rigidly connected together with wooden distance pieces—an arrangement which is claimed to give an equal magnetic field through the length of the magnet and to avoid danger of short-circuiting when crossing other tracks. The magnets are compound wound, one winding being in series with the motors, and the other across the 500 volts. Six cells are carried for the initial pick-up. With a magnet system 4 feet longer than the collector shoe, the time element for the operation of the circuit closers permits a speed of 20 miles per hour. A very satisfactory form of shoe is composed of a contact strip of non-magnetic material, a piece of heavy rubber and linen hose, and a wooden support, all clamped together. E. H. C.-H.

1598. *Soldered Bonds, &c., at Seattle, U.S.A.* (Street Rly. Journ. 17. pp. 270–275, April, 1901.)—Soldered leaf bonds are now the standard in the Seattle Electric Company. Seven layers of sheet copper, together 0·25 inch thick by 1 inch wide are tinned for 1¼ inches at each end and bent into U-shape in the middle. Holes are bored in each end, so that molten solder will run to the centre as well as round the edges. In new construction with 72-lb. Shanghai T-rail, these bonds are sweated under the base, the fished rails being inverted for the purpose. The rail is heated with a powerful gasoline torch; common soldering acid is used, the flow of solder being assisted by a soldering iron. When the bond is standing in a pool of solder, it is held down tight and water applied to wash off the acid and cool the joint. The essential for success is plenty of heat quickly applied. A stone is put between the ends to prevent the heat at one end melting the joint at the other. Two men can solder both ends of a bond in five minutes. In paved streets a tin box is slipped over the bond before concrete is put round it.

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[1] Non-electrical Automobiles are described in the section dealing with steam and gas engines.

On single lines the Seattle Company use a system of block signalling with lamps operated by the motor man pulling cords hanging from switches attached to the trolley-wire. On the steepest routes, cable cars alone are possible. On others, a counterweight system is used at certain grades. Details of conduit, tunnel, grip, &c., are given. E. H. C.-H.

1599. *Electric Vehicles for Public Service.* **K. Simons.** (Elektrotechn. Zeitschr. 22. pp. 351–354, April 18, 1901.—Paper read before the Elektrotechnische Gesellschaft, Cologne, Dec. 19, 1900.)—The author considers the various types of electric automobiles, the performance of batteries, efficiencies of motors, cost of vehicles, &c., and concludes that electric cabs cannot afford to stand idle on ranks, but must be concentrated in depôts, like fire engines, so that inspection and repairs can be constantly done by the unemployed drivers. E. H. C.-H.

1600. *Magnetic Field Produced by Electric Tramways.* **A. W. Rücker.** (Phil. Mag. 1. pp. 423–431, April, 1901. Paper read before the Physical Society of London.)—In the case of a straight line of tramway the magnetic field at any point due to the current in the trolley-wire can be easily calculated, but that due to the return current is somewhat uncertain. In the present paper the return current is treated in two different ways. In the first it is treated as if part of the current was carried back by an insulated rail while the remainder returned through the earth (supposed to have uniform conductivity), the earth current being treated as a problem in conduction between a source and a sink. The current in the rail is called the "*equivalent uniform current*" and is of course different from the "*mean*" current. Experiments made on a line at Stockton, two miles long, gave results which would agree with those given by a current in the rails equal to 84 per cent. of the whole, the remaining 16 per cent. returning by the earth. In the second method it is assumed that the leakage at each point of the rail is proportional to the difference of potential between that point and the earth. The problem is then similar to that of a Fourier bar. This problem is dealt with mathematically at some length. When applied to the Stockton experiments it gives a "*mean*" current in the rails of 86·7 to 87·4 per cent. and a minimum current in the rail of 80·6 to 81·4 per cent. J. B. H.

1601. *Practical Application of the Theory of Magnetic Disturbance by Earth Currents.* **R. T. Glazebrook.** (Phil. Mag. 1. pp. 432–442, April, 1901. Paper read before the Physical Society of London.)—This paper contains some applications of Rücker's theory. In similar circuits similarly placed, the vertical force varies as the linear dimensions of the circuit multiplied by the current. If the same number of cars per mile run on all circuits, the currents are proportional to the linear dimensions. Hence the vertical force would then vary as the square of the linear dimensions.

The results of Rücker's Stockton experiments [see preceding Abstract] are compared with those given by Parry [Abstract No. 2514 (1900)]. In the former the ratio of the external conductivity to the internal conductivity in the Fourier bar problem ($\mu = h/k$) is 0·64, while in the latter it is 0·42.

The vertical force at a point situated at a perpendicular distance y from the middle of a line of length a, is—

$$F_v = \frac{0·62}{4} \lambda \mu^2 \frac{a^4}{y} \frac{1}{\sqrt{4y^2 + a^2}} \times 10^{-5},$$

where λ is the ratio of the current to the length of line—

$$I = \lambda a.$$

The total leakage in length a—

$$= \frac{h\nu a^3}{8} = \frac{\lambda \mu^2 a^3}{8}$$

where ν is the potential-difference between two points one mile apart. Suppose we wish to find the connection between the length of the line and its distance from the observatory, so that when its effect is a maximum it may be less than a given quantity, δ say. Calculate in absolute units the leakage in a rail one mile long when carrying the maximum current required to drive the maximum number of cars in the mile. Let the result be L c.g.s. units of current. Then a must not exceed the value given by the equation—

$$1·24 \times L \times \frac{a^4}{y} \frac{1}{\sqrt{(a^2 + 4y^2)}} 10^{-5} = \delta.$$

Two miles of track carrying a current of 300 amperes with a potential-difference of 7 volts between the ends might produce a vertical magnetic force of $0·5 \times 10^{-5}$ units on an observatory at a distance of three miles. J. B. H.

ELECTRIC LAMPS AND LIGHTING.

1602. *Street Lighting in St. Louis.* **H. H. Humphrey.** (West. Electn. 28. pp. 180–181, March 16, 1901. Abstract of a paper read before the Engineers' Club of St. Louis, Nov. 21, 1900.)—The lighting is by six pairs of 110-light series arc dynamos, each light requiring 500 watts. Each pair of arc machines is driven by a 200-h.p., direct-current, 500-volt motor. Five sets of machines are able to supply the present city lights, leaving one set as a reserve. The average efficiency of transformation of the plant is 80½ per cent. ; probably one-third of the 19½ per cent. loss could have been saved by driving the generators direct from the engine, but it is considered that the practical advantages of the method employed more than compensate for the extra loss in efficiency. The street lamps are direct-current, series, enclosed-arcs suspended on iron poles ; the candle-power of these lamps is 16 per cent. greater than that of the alternating series enclosed-arc lamp for an equal expenditure of energy at the arc. There are three underground 105-lamp and seven overhead 90-lamp circuits. Some trouble was encountered owing to the static discharge from the underground cables, which resulted in the short-circuiting of arc-lamps through the insulation at the top of the enclosing globe. This evil was satisfactorily remedied by soldering together the lead sheathing of the cables at the manholes and switchboard, and attaching to the copper of each circuit at the switchboard a rotating static-discharger, consisting of a Leyden-jar with its outer coating earthed. The city contract includes, besides the arc-lights, a number of incandescent lights throughout the city ; these are supplied from the company's regular three-wire 235–470-volt mains, and are turned on and off by switches actuated by the currents in the arc-light circuits, each switch controlling the incandescent lamps in its neighbourhood. J. H.

TELEGRAPHY AND TELEPHONY.

1603. *Cable Recorder.* **C. Jaulin.** (Journ. Télégraph. 25. pp. 173–175, June, 1901.)—An invention of M. Ader. The currents pass through a fine, long, copper wire, diameter 0·02 mm., weighing 1 mg., placed vertically between the poles of a strong permanent magnet. The wire undergoes displacement at its centre, on one side or the other according to the direction of the current, its vertical position of rest being assured by the wire being under tension. This force can be regulated by a stretched silk thread acted upon by a weight. The wire is in a very narrow space between poles of not more than 0·5 mm. in breadth. The sensibility of this receiver is such that signals are produced by a current of ⅓ of a micro-ampere. It is actuated by feebler currents and more quickly than the siphon recorder. A light shines through an orifice in one polar piece on to the middle of the wire, and through a slit in the other polar piece, the shadow of the wire being thrown upon sensitised paper. To emphasise this shadow, the wire has a little sheath of very light feather pith. A small motor actuates the tape, and there are baths within a cabinet for developing, washing, and fixing the photographic trace. The inventor claims, by trial made on an Atlantic cable in 1896, that transmission was 60 per cent. quicker than with the siphon recorder. E. O. W.

1604. *Telephony on Telegraph Lines.* **O. Canter.** (Elektrotechn. Zeitschr. 22. p. 302, April 4, 1901.)—The secondary of the microphone induction-coil is connected in the telegraph circuit, between the telegraph apparatus and the line; from between the induction coil and telegraph apparatus, a connection is made to earth through a condenser of about 0·2 microfarad capacity. The telephone apparatus is thus entirely independent of the telegraph line, and the condenser prevents the telegraph currents from affecting the telephone The author describes some suitable forms of condenser made in the shape of a coil, either by winding two parallel wires on a bobbin or by rolling up strips of tin-foil and paper. G. H. B.

REFERENCES.

1605. *Wireless Telegraphy.* **M. Lamotte.** (Écl. Électr. 26. pp. 432–444, March 23, 1901.)—A good *résumé* of recent papers on this subject. J. E.-M.

1606. *Party-Line Telephone System.* **E. Pierard.** (Soc. Belge Élect., Bull. 17. pp. 506–510, 1900.)—The author describes and illustrates connections for numerous stations on one metallic circuit line—in series and in parallel; also a method of using one line for calling, the other for speaking. J. E. K.

1607. *Automatic Telephone Exchange at New Bedford, Mass.* **A. D. Adams.** (Elect. World and Engineer, 37. pp. 225–228, Feb. 9, 1901.)—The author describes the automatic exchange, fitted with Strowger apparatus. J. E. K.

1608. *Telephone Cable under River.* (Elect. World and Engineer, 37. pp. 436–438, March 16, 1901.)—This article describes construction of shafts and tunnel for carrying cables under Milwaukee River. Plans and illustrations are given. J. E. K.